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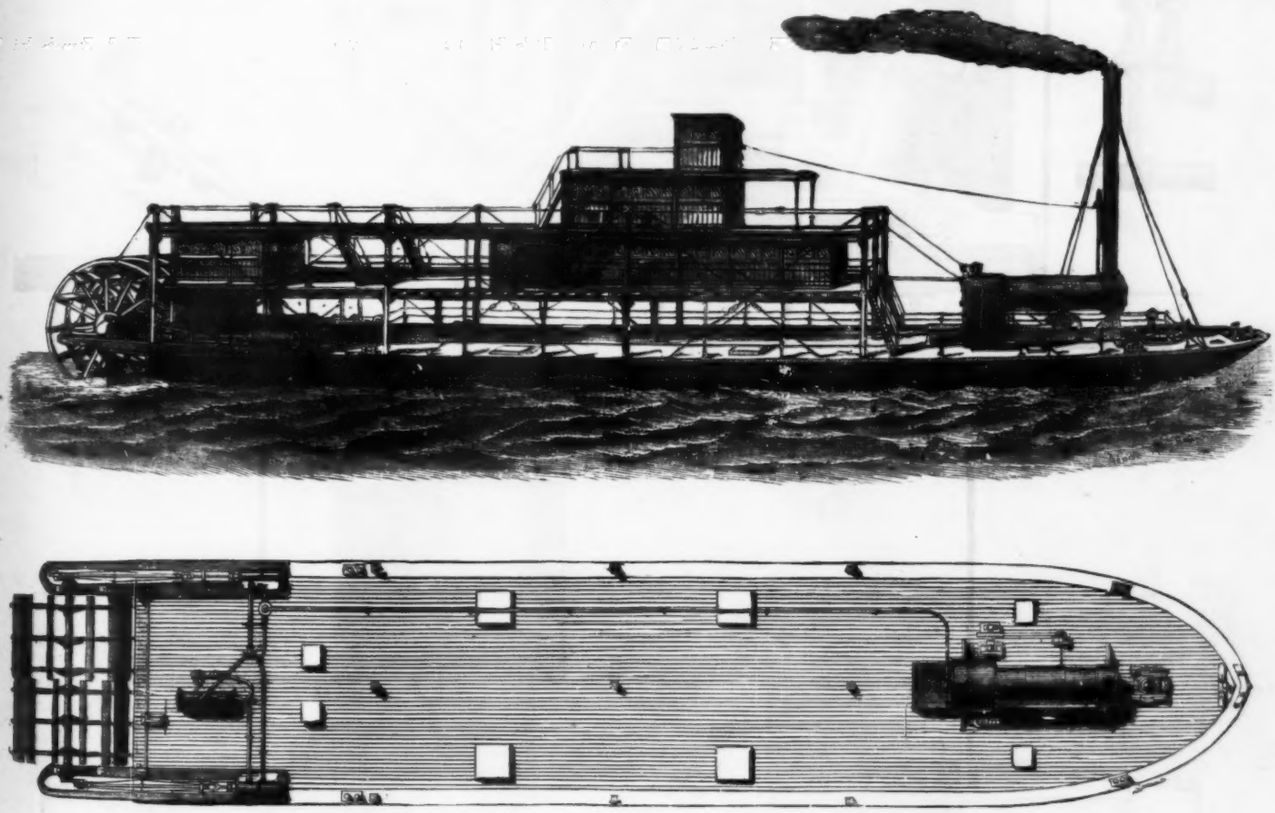
## NEW STERN-WHEEL STEAMERS.

MESSRS. YARROW & Co. received orders for two other stern-wheel steamers from the government of the United States of Colombia, which boats were completed last November. We illustrate one.

They are sisters, 130 ft. long, 28 ft. beam. Their draught, empty, is 12 in.; loaded with 90 tons, it is 24 in.; and their speed will be about sixteen miles an hour. They are constructed of steel plates, 3-16 in. thick, and are carefully stiffened by wrought iron trusses which can be screwed up and adjusted.

The engines are compound surface condensing. The high-pressure cylinder is 15 in., and the low-pressure cylinder 27 in. diameter, with a stroke for both of 4 ft. 6 in. The boiler pressure is 160 lb. Steam can be admitted direct to both cylinders for ascending rapids, a reducing valve taking down the pressure in the large cylinder to 60 lb. The boiler is of the locomotive type, with two fire-boxes of large size for wood, which can be fired alternately. A fan is used to maintain a sharp draught.

The vessels are fitted up with every convenience for passengers, and are each divided into fourteen water-tight compartments, and have a spoon bow and three rudders at the stern.—*The Engineer.*



## STERN-WHEEL MAIL STEAMER FOR SOUTH AMERICA.

## THE FERRY STEAMER LOFTUS PERKINS.—BOILER PRESSURE 450 LB. PER INCH.

THE Tyne General Ferry Company, with a view to obtaining greater economy in the working of their steamers last year, fitted one of their old boats, the Lady James, with the Perkins engine, and renamed the vessel the Loftus Perkins. We illustrate her engines on pp. 3448–50. It might be well to mention before proceeding to the description of the machinery that great difficulties stood in the way of getting compound condensing engines expanding steam twenty-four times, as the Perkins engines do, into a space previously occupied by ordinary oscillating engines working nearly full stroke with 35 lb. average pressure on the piston and a jet condenser. The load also on all the working parts was very high, the crank pins carrying as much as 1,172 lb. per square inch of bearing surface; the machinery has been kept to the same weight as the old engines, doubling at the same time the area of the low-pressure cylinder, and considerably reducing the load on all the working parts by increasing their proportions. This would have been impossible but for the fact that the boiler with water weighed as nearly as possible half the weight of the old boiler, viz., 7 tons 10 cwt. in place of 15 tons.

Figs. 1 and 2 are front and side elevations of the engine complete. The cylinders are inverted over wrought iron beams, each engine having a pair. These beams are hung at the forward end and drive cranks 8½ in. throw by return connecting rods. The condenser is placed between the engines, on top of it a pair of heavy plummer blocks are cast, carrying the intermediate portion of the crank shaft 6 in. diameter, and it is intended that the center shaft and blocks shall be strong enough to carry all the reciprocating strain of the engine and relieve the two outside frames from all but the weight of the shaft and wheels and turning strains. The outside frames and condensers carry the main cross-head guides, and brackets on the frames and condenser secure all together under the cylinders, and form the bed upon which they are bolted. The air and circulating pumps, 14 in. and 13½ in. diameter and 6 in. stroke, and feed and bilge pumps, each 3½ in. diameter and 6 in. stroke, are driven by crossheads from pins on the main beams. All the cylinders and valve boxes are covered in with a wrought iron double casing filled with vegetable black to keep in the heat.

Figs. 3 and 4 are sectional elevation and plan of the high-pressure cylinder, and Figs. 9, 10, and 11, sections of the inlet valves; Figs. 12 and 13 give sections of the exhaust valve; and Figs. 14 and 15 show joints in the piston packing rings. The high-pressure cylinder is 10 in. diameter, by 2 ft. stroke, and is steam jacketed with a coil of wrought iron pipe cast in the thickness of the cylinder. The coil is ¼ in. bore, ⅝ in. diameter outside. This cylinder takes steam for about ⅝ of its stroke, and is single-acting.

Figs. 5 and 6 are a sectional elevation and plan of the medium cylinder. It is 20 in. diameter, and like the high-pressure cylinder is cast with a coil of pipe to form the jacket, and is also single-acting. Fig. 25 is a section through the exhaust valve box of this cylinder. Fig. 12 is its steam valve, being also the exhaust from the high-pressure cylinder. The two pistons, high and medium, are on one rod, and make the starboard engine.

Figs. 7 and 8 are sectional elevation and plan of the low-pressure cylinder. This cylinder is double-acting, and steam is distributed by means of an ordinary slide valve of Perkins' metal with a cut-off valve on its back, cutting off steam at ¼ in. stroke. The cylinder is 28 in. diameter, and is jacketed as the others are. No difficulty whatever was found in constructing these cylinders, and the perfection of their working surfaces when last surveyed, we understand, left nothing to be desired.

Figs. 19 and 20 are sections of the inlet valve to the high-pressure, 2¾ in. diameter in the bore; Figs. 21 and 22, exhaust valve from high-pressure cylinder, 3½ in. diameter in the bore; and Figs. 23 and 24 show the exhaust valve from the medium-pressure cylinder, 6½ in. in bore.

Figs. 26 and 28 show the weigh shaft for working high and medium valves, and Figs. 27 and 29 the wrought iron carriage on the valve rod, and the sliding block through which the motion is imparted. The thick black lines delineate the action of the lever. The angles on either side of the center line of the spindle are traversed while the valve is on its seat. The versed sine is the amount of space the valve rod leaves the valve after it is landed on its seat, the valve being loose on the spindle. This space is very small —from ⅛ in. to $\frac{3}{16}$ in.—and is passed over by the spindle during half a revolution. There is no noise whatever, either at landing the valve on its seat, or striking it again at the time of opening, and the wear at the end of the rod where it touches the valve is exceedingly small.

Fig. 17 is a transverse and Fig. 18 a longitudinal section of the condenser. The tubes and plates are of wrought iron galvanized. The tubes are $1\frac{1}{16}$ in. diameter outside, and ⅞ in. bore. One end is welded up solid, and the other screwed and calked into a thick wrought iron plate. There is an inner tube in each, ⅜ in. diameter outside, ¼ in. bore, for circulating the water. The object in making the tubes thick, and securing them in this substantial manner, is to prevent the possibility of any mixing of the water used in condensing with that used in the boiler. Each tube is free to expand and contract by itself without endangering the joints, and, as far as the tubes and joints are concerned, is practically indestructible. The water circulates first through the inner tube to the end of the large tube, then back through the space between them to the circulating pump, the water being drawn through the condenser. The surface exposed to the steam is 430 square feet.

The low-pressure starting valve is for admitting live steam to the low-pressure engine when the high-pressure engine is on the dead center. The boiler has 19 square feet of fire-grate, a natural draught, and 760 square feet of heating surface. The fire-box is rectangular in shape, seven rings high, and there are 10 straight tubes above the fire 4 ft. 7 in. long in each section, and seventeen sections wide. These sections are 3¼ in. apart, and the fire rises vertically among them. The space occupied by the boiler is 5 ft. 3½ in. from front to back, 5 ft. 10 in. wide, and 9 ft. 4 in. high. The boiler has, we understand, cost nothing for repairs since it commenced working, and has been three times surveyed and passed by the Board of Trade.

The boat is 100 ft. long, 13 ft. 10 in. beam, 6½ ft. deep, 99 tons builders' measurement, and 36 tons register, 3 ft. 10 in. draught, representing a displacement of 62 tons. Paddle wheels are 10 ft. effective diameter. She is certified to

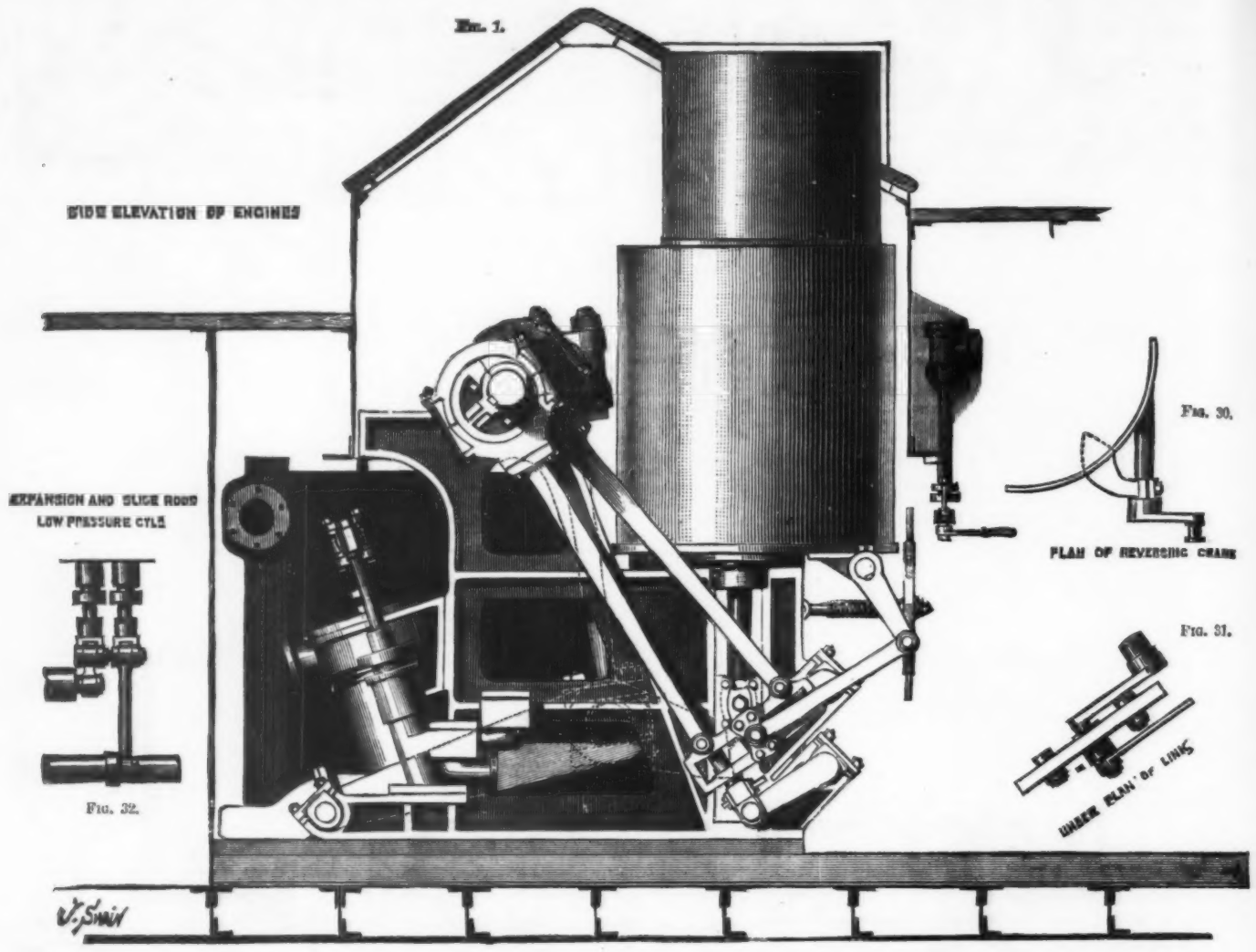
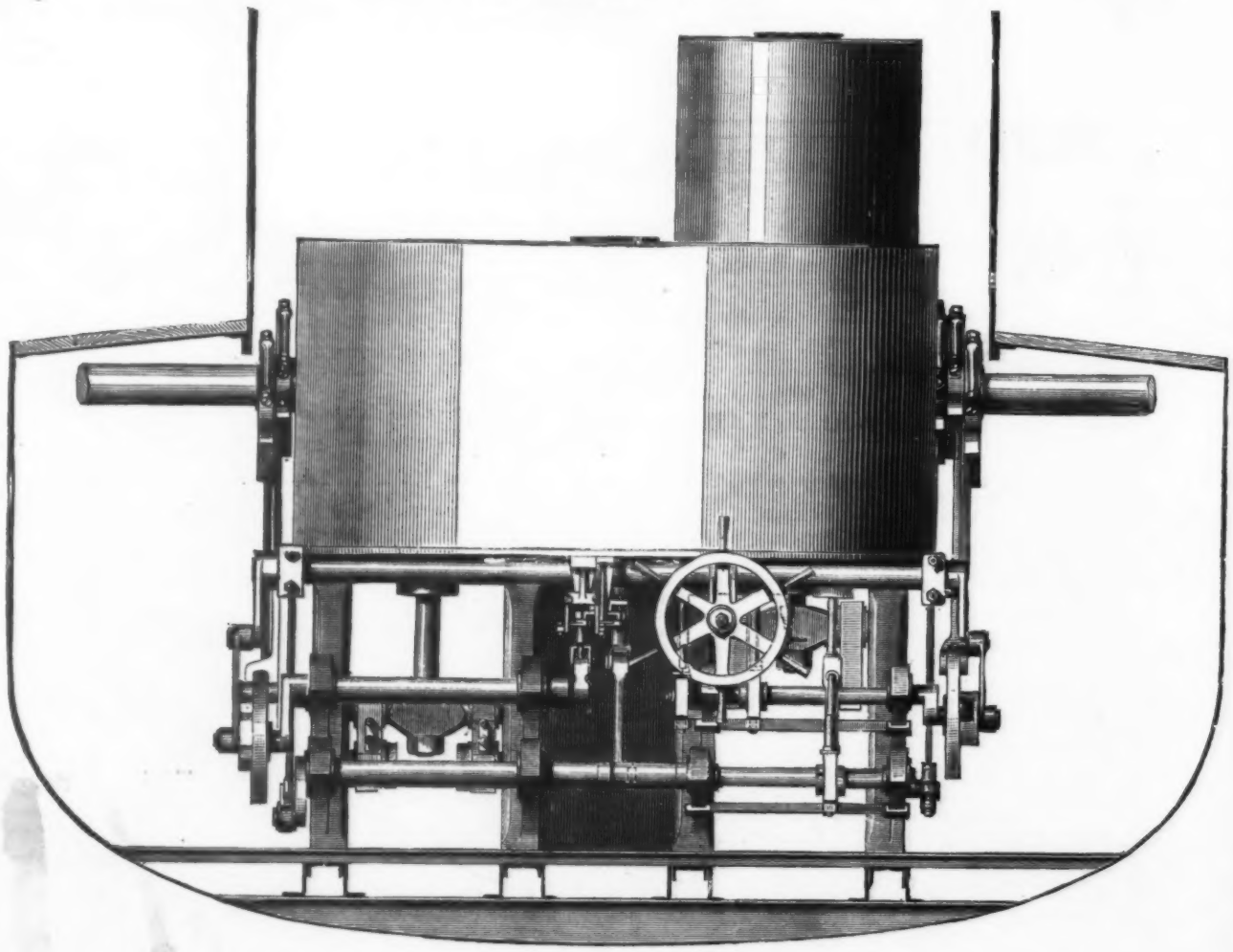
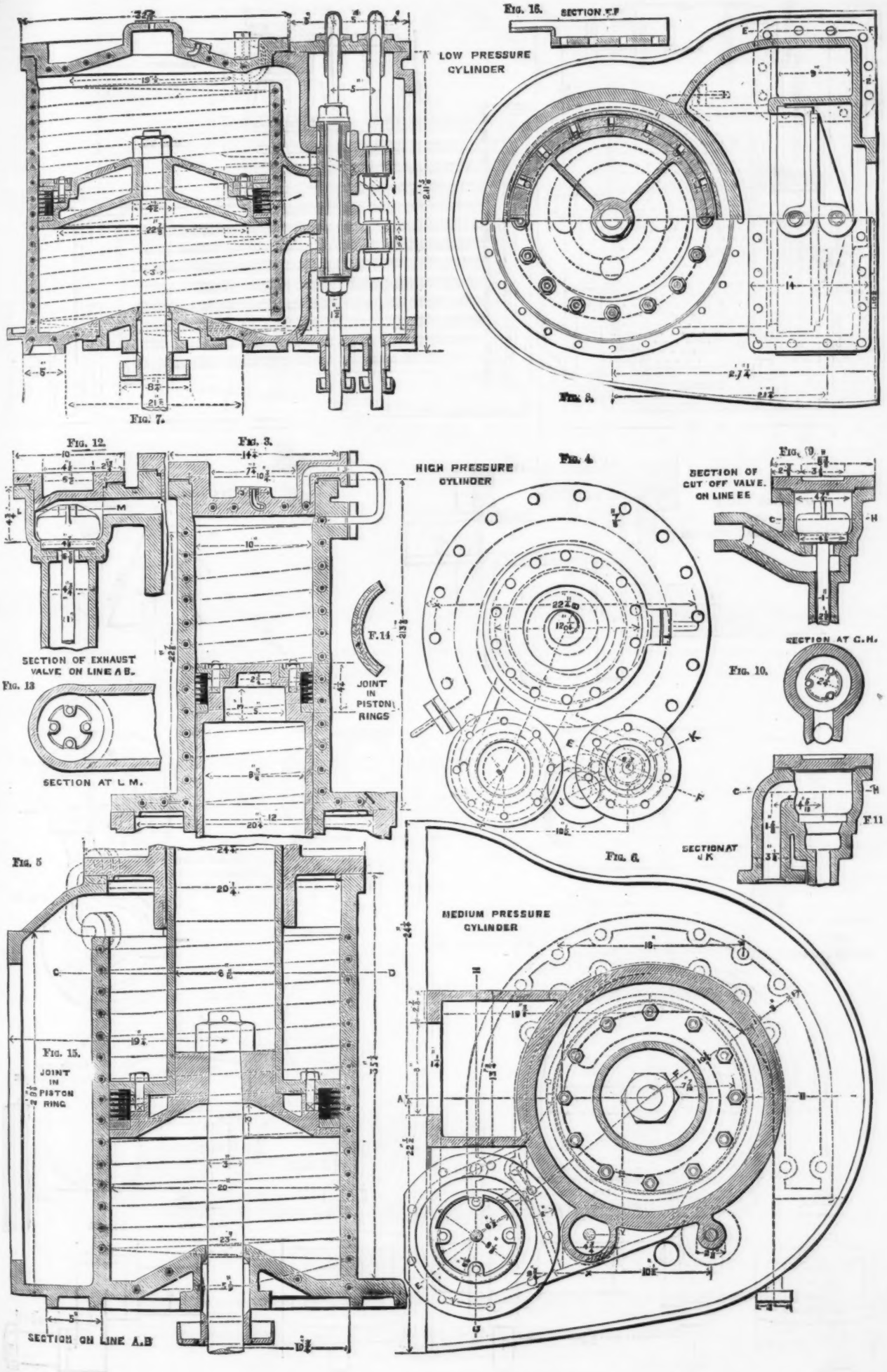


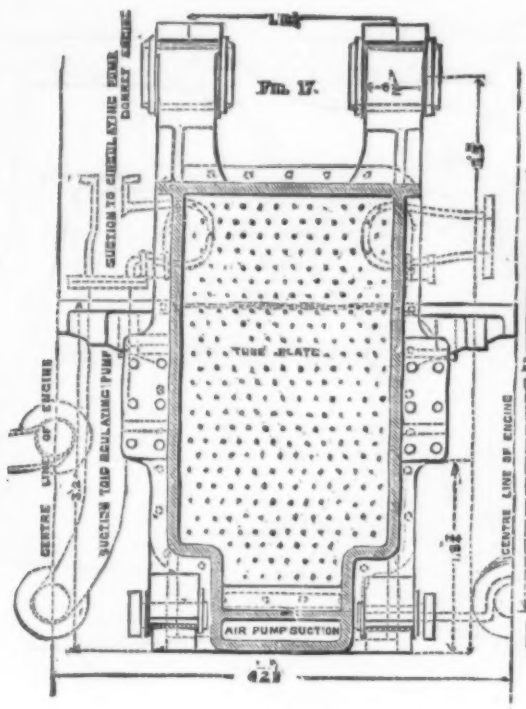

FIG. 2.—TRANSVERSE SECTION.

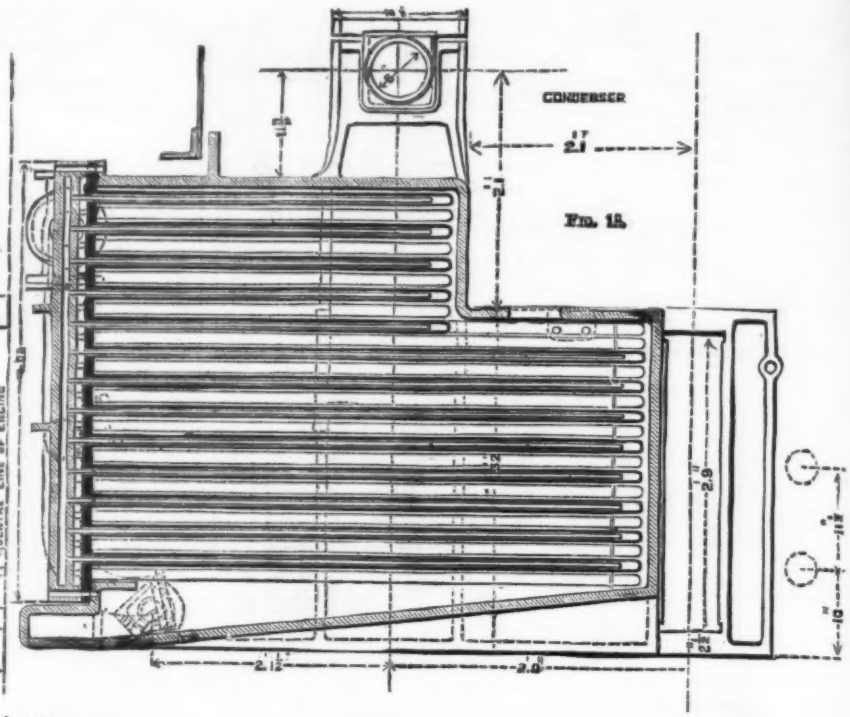


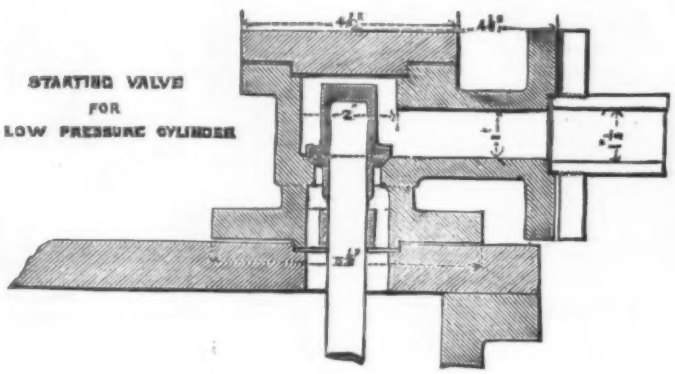
COMPOUND ENGINES OF THE FERRYBOAT LOFTUS PERKINS.

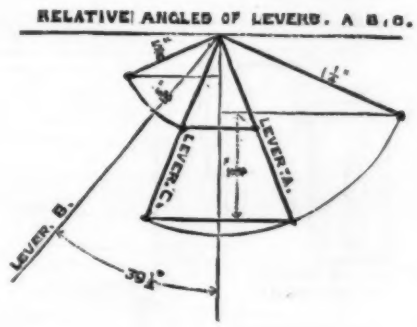

LOW PRESSURE CYLINDER
HIGH PRESSURE CYLINDER
MEDIUM PRESSURE CYLINDER
JOINT IN PISTON RINGS
SECTION OF EXHAUST VALVE ON LINE A B.
SECTION AT L M.
SECTION OF CUT OFF VALVE ON LINE E E
SECTION AT G H.
SECTION AT J K
JOINT IN PISTON RING
SECTION ON LINE A B

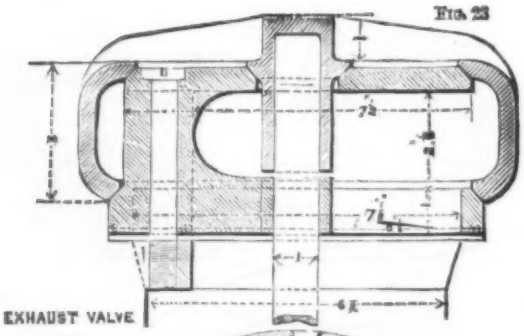
COMPOUND ENGINES OF THE FERRYBOAT LOFTUS PERKINS.

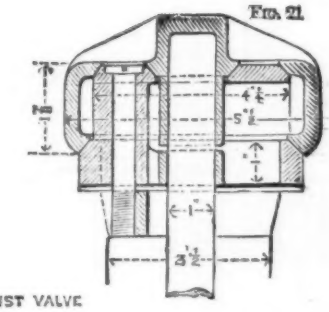


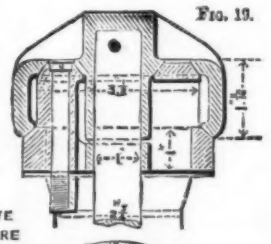



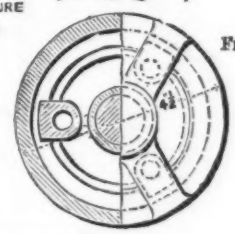



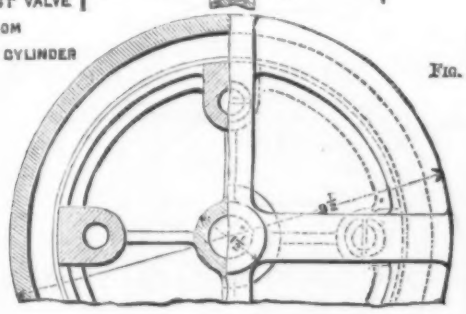



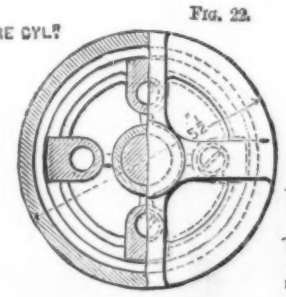



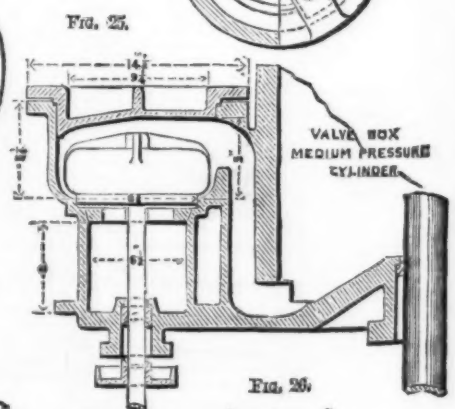



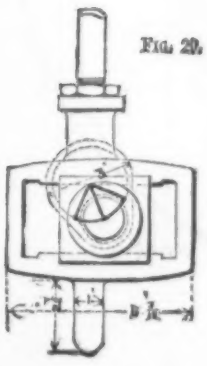



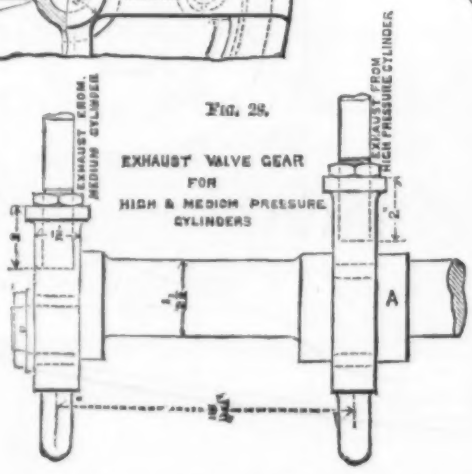



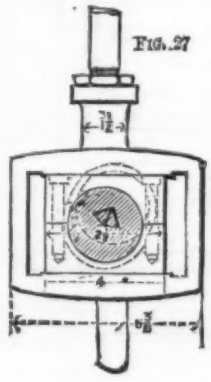



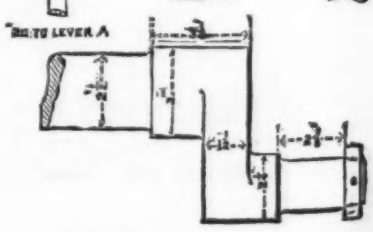




COMPOUND ENGINES OF THE FERRYBOAT LOFTUS PERKINS.

carry 270 passengers; speed 10 miles per hour, the engines indicating 150 horse power, and working steam regularly to 430 lb. per square inch. The boiler was tested to 2,000 lb. per square inch. During the time the boat was on the passenger line, with a Board of Trade certificate, she ran 5,382 miles, but having cracked her port frame and broken her crank pin is now laid off for alterations. The boiler, however, has been drilled for the surveyors and found to be perfectly clean and free from scale.—*The Engineer.*

## TWEDDELL'S HYDRAULIC CAPSTAN AND WINDLASS.

We present herewith figures of two of the ingenious devices invented by Mr. Tweddell for the utilization of water pressure as a motive power. They represent two capstans of different models, which are now being employed on the docks and at the railway stations in England for unloading freight.

The first of these is a capstan, which is designed to be actuated by a three-cylinder Brotherhood machine, and is

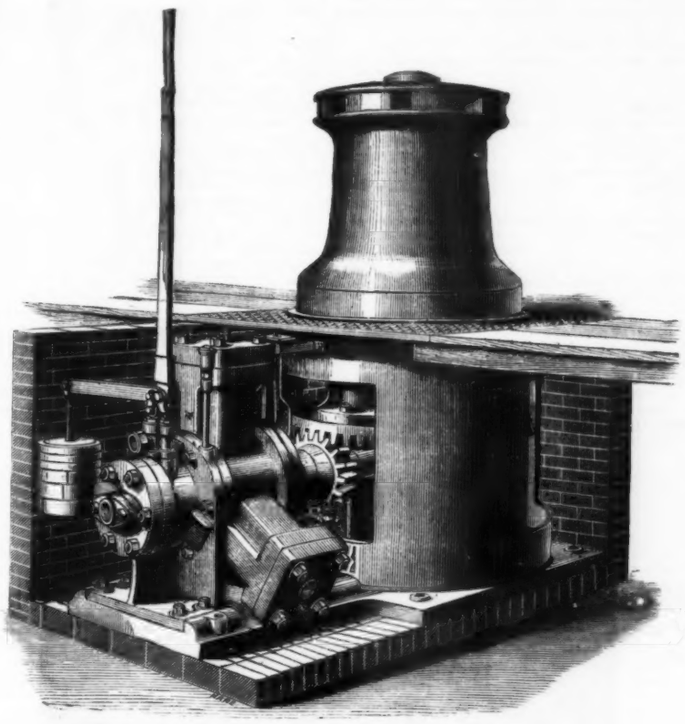


FIG. 1.—TWEDDELL'S HYDRAULIC CAPSTAN AND WINDLASS.

put in motion by means of a vertical lever; while the mechanism with the upright shaft, which carries the capstan, is governed by a strong, conical gearing. This same capstan may be changed so as to be worked by manual labor and the use of bars, by doing away with the upright lever and shutting off the supply of water under pressure.

The second apparatus is a horizontal windlass, which, like the preceding, is actuated by a three-cylinder Brotherhood machine. It is set in operation by pressing with the foot

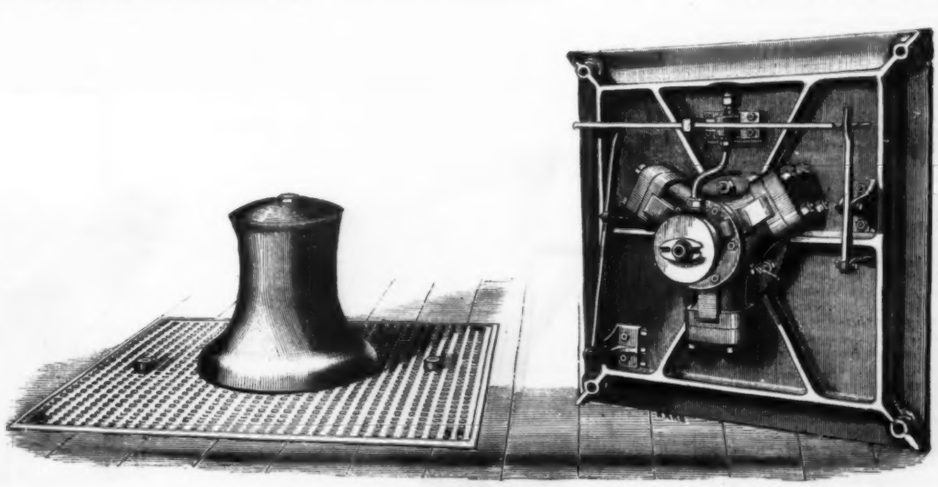


FIG. 2.—TWEDDELL'S HYDRAULIC CAPSTAN AND WINDLASS.

on a pedal which opens the supply-cock. On removal of the pressure, the water supply is checked and the windlass brought to a standstill. This apparatus is used at the railway stations of London as an economical substitute for horse power in moving cars and carts during the process of unloading and transferring freight.

The two cuts show the arrangement of the apparatus in sufficient detail to make them readily understood, and it is only necessary to add that the latter have been thus far used with most satisfactory results.

## WHEN IS A SAFETY VALVE NOT A SAFETY VALVE?

GENERAL ANSWER.—When it is a little "*jammed.*"

The multitude of patent devices called safety valves, and the frequency of boiler explosions which arise from overloaded and defective safety valves of the simpler forms, suggest the importance of the greatest care in the application and management of this vital organ of the steam generating system. The idea is too prevalent among boiler attendants and engineers of average intelligence, that, once properly proportioned and adjusted, their apparatus is in a permanently safe condition, but the number of answers that may be given to the above proposition attests the ignorance of first principles of safety which so often appears in the neglect of the safety valve or in so tampering with it as to render it inoperative. A few of the more frequent defects are suggested by the following answers:

A safety valve is not a safety valve:

1. When the fireman in response to the demand of the owner for more steam, or to stop a continual leak, hangs his fire rake or poker on the lever so that the handle hangs down over the boiler side wall at an angle and jams the lever against its guides.

2. When a few bricks or an old grate bar is added to the regular weight for the same purpose.

3. When the valve has not been raised for a long time and has become cemented to its seat by corrosion.

4. When the stem is bent or corroded so as to bind in the bonnet.

5. When the stem has been painted to prevent corrosion with a gummy stuff that is baked fast into the joint by the heat.

6. When the stem is too short, and the lever slopes down toward the weight and jams the stem hard against the sides of its bearing in the bonnet, causing it to stick, as well as the valve to leak.

7. When the top end of the stem is flat, so that on raising its bearing is changed from the general surface of the top to the edge next to the fulcrum, thereby causing an angular bearing that jams or causes it to drag, as well as alters the proportions unfavorably between the long and short arm of the lever.

8. When a stop valve is placed between the safety valve and the boiler, which may be left closed through carelessness or inattention.

9. When a plug has been left in the only steam outlet inside the boiler to stop steam or hot water coming from an adjoining boiler through a leaky stop valve while cleaning or repairs is going on.

10. When a wooden strut is wedged between the lever and ceiling or roof of the boiler house.

11. When the escape pipe is too small to allow of the free discharge of the full volume of steam which the boiler is capable of generating.

12. When the escape pipe is so located as to retain a quantity of water in a low place or pocket, which may come from external rains or internal condensation of steam and become frozen over Sunday or a holiday, so as to effectually plug the pipes and prevent the escape of the steam except around the stem through the bonnet.

13. When the stem and pins are too nicely fitted, and no allowance made for dirt, dust, and ashes, or the arc described by the stem pin as it rises.

14. When the apparatus is inaccessible, invisible, and so close to the roof or ceiling that the settling of them from an overload prevents the raising of the lever.

15. When to a light, brass bodied valve of the wing type, having on one side a steam, and on the other a safety outlet, there is attached a long unsupported steam pipe, which by its leverage so distorts the valve body as to jam the wings and cause the valve to leak, and effectually prevent it from leaving its seat.

16. When a patent spring valve has been unequally screwed down, so as to tilt the cross bar on which the spring bears and through which the stem passes as a guide, thereby jamming the stem and making it inoperative.

Should these propositions fall under the scrutiny of any veteran engineer who has never done or permitted anything of this kind, and who will exclaim, "Any man who don't know any better than to do or neglect to do such things is little better than a natural fool or a lunatic, and has no business with a steam boiler," to him I say, my contempt for such stupidity is not less than his. So the careful business man who is precise and methodical in all his movements, and who has been trained in a school where mistakes are about equivalent to crimes, and who is especially particular to properly superscribe all his postal matter and to see that it is duly stamped and sealed, has no better opinion of or patience with the "careless fool," as he calls him who sends a postal card without a superscription, or sends a draft in an unsealed envelope, or dispatches an important message or business order unstamped. Yet we are informed by postal statistics that thousands of such mistakes occur annually. While I do not pretend to say that these things which you and I condemn as acts of criminal carelessness are by any means the prevailing practice even among the most ignorant and foolhardy of boiler attendants, or that they are often repeated by the same person, still these answers are none of them fictions or overdrawn pictures of facts. Though you and I need not the suggestions which they offer, yet they are important, and as curiosities of carelessness and ignorance they may serve as reminders that no one is infallible, and that "to err is human."

We often hear of one of the old corps blowing himself up without leaving an account of how it was done, and notably within a few days one who had the reputation of being a careful and intelligent engineer, and was in the same employ for many years. Grave suspicions are entertained by at least one observer that his safety valve was *jammed.*—"*T*" *Water in the Locomotive.*

## OSCILLATION AND VIBRATION OF MILL BUILDINGS.

BEFORE citing any examples of the jarring of mills, I desire to call attention to the character of such motions, and the difference between oscillation and vibration, and then, with this distinction and its causes understood, we will consider a few cases of the vibration of factories and the nature of the remedy.

The motion of a pulsating body is either oscillation or vibration: the first being caused by external forces; and the second the consequence of forces, one of which is the cohesive force within the body, binding its molecules together, and dependent for its character upon the elasticity of the body. To illustrate: If a suspended wire is struck, the forces of the blow and of gravitation cause it to oscillate; if the same wire is strained between two points, the forces of the blow and of elasticity cause it to vibrate.

The rapidity of this vibration is governed by the dimensions, elasticity, and tension of the body; and every mass

will vibrate at a constant velocity, whenever that vibration is produced by adequate causes and conditions. Not only every piano-forte wire and organ pipe, but every bridge and factory has its key-note. As the vibrations of the communicating air will force the piano or organ to answer in harmonious response to the tone of the voice, so the structure will reply to the proper vibratory force.

The shaking of a mill is chiefly limited to the vibration of the elastic floor and beams; while the swaying of the whole building is generally caused by oscillation. Both of these motions appear in the same building, but oscillation is due to poor construction, while vibration is produced by impulses synchronous with the key-note of the building, and bears no relation to the solidity of construction. In a certain district of New England many factories were built during the war, when high prices, haste for completion, and, perhaps, limited capital, resulted in poorly constructed buildings. Shabbiness prevails everywhere, the walls are too light, the beams too small, and the floor planks too thin, when compared with structures built by our leading engineers as standards.

In many instances, the weight of the machinery has deflected the floors several inches, and in others, additional columns have been necessary to keep the floors level. The oscillation of these mills is excessive, but I do not recall an instance of extreme vibration.

In the practical construction of machinery, the revolving portions are not *absolutely* balanced; and when one considers the immense weight of revolving parts of mill machinery and its velocity, it seems as if the aggregation of unbalanced centrifugal forces would overturn, instead of merely jar, a mill; and such a destructive result would undoubtedly ensue if these irregularities acted in unison, instead of opposing each other.

Let us consider the characteristics of a vibrating mill floor by comparison with those of a metal plate when vibrating under conditions which are simple and easily controlled.

If a metal plate is supported at the center, and a violin bow be drawn across the edge, the plate will not vibrate as a whole, but in divisions which are readily distinguished if sand has been dusted on the plate, as the vibrating portions will jar the sand to the nodes or dividing lines which are at rest. If the plate is a square one, and the bow drawn at the corner, while the free vibration is damped by resting the finger at one side, midway between the two corners, the sand will gather in two lines, dividing the plate into four equal squares; if the bow is drawn at the middle of one side and the finger placed at one of the corners, the ridges of sand will divide the plate along the two diagonals extending from corner to corner; and by varying the positions of the damping points and the bow, the nodal divisions resolve into complex and curious curves and lines. A vibrating mill floor is, under similar conditions, except that the contact of pillars and surrounding walls, as far as they restrain free vibration, complicates the details of these vibrating divisions beyond the power of analysis, except to show that the vibration of the floor is separated into numerous and irregular divisions.

The effect of these forces has been observed in many factories, and for examples I would refer you to the ring-spinning rooms, where the frames are of the same manufacture, and supposed to be operated under identical conditions; some of them will shake violently, while others beside them run as steadily as could be desired.

Some of the gas-pipes extending from the ceiling in the upper story of a flat-roofed mill were observed to be in motion, while others were stationary, showing some of the divisions in the vibrations of the roof. On account of their rigidity, gas-pipes do not indicate the divisions of vibration as sensitively as hanging lamps. In a mill at Haydenville, Mass., the vertical motion of certain hanging lamps showed that there was a vibration of the floor amounting to an inch in some places. Other lamps moved less and some were still.

One of the most delicate indications was in the unoccupied attic of a mill at Exeter, N. H., where the agent had judiciously placed upon the floor numerous fire pails filled with water. The surfaces moved in unison with the vibration of the floor, generally swaying, some traversed by successive lines of waves, whose direction varied in different pails, others, evidently over nodal lines, were at rest, while a few, which were situated upon centers of vibration, were covered with ripples such as are produced when a hanging pail of water is struck underneath. Of two pails situated within a foot of each other, one indicated by its ripples that its position was over a center of greatest vibration, while the other showed by its wave-like motion that its location was near such a point of greatest vibration, but not over it. The vibrations of the floor are in waves moving up and down without any progression, and the character of the motions of the water in these pails was concurrent with such action.

It is well known that some notes on a church organ will cause only certain portions of that church to vibrate. I have been informed that in some portions of the picker building of a Woonsocket mill the vibration jarred the dust to the nodal lines, showing the divisions clearly.

Although these areas of vibration are modified by the columns and walls, yet they are not coincident with any divisions of the floor, because excessive vibration has been observed near such places, while the portions away from such support were at rest, but the reverse is generally the case, and most perfect repose is near the points of greatest stability, where one would naturally expect to find it.

The superintendent of a New Hampshire mill, when in the factory on Sunday, was greatly surprised at the shaking of the building. He observed that the water was flowing in broken sheets over the dam, and presumed that the pulsations of air were synchronous with the key-note of the mill; continuing his observations, he learned that with a greater or a smaller flow of water over the dam, the mill was at rest; and also with the scuttle in the roof open, so that the puffs of outside air were in free communication with the interior of the mill, the vibration was much greater than when the scuttle was closed.

At Centerdale, R. I., the water flowing over the dam caused at times a great vibration in the mill. This has been stopped by fastening vertical pieces of plank, at intervals of ten feet, against the front of the dam, and projecting upwards so as to break the long sheet of water into numerous short falls whose key-note was different from that of the whole sheet of water which they displaced.

At the Essex Woolen Co., mill number 8 is sometimes thrown into vibration by the water flowing over the dam, and when this happens the watchman on duty alters the note of the dam by opening the waste gate, and the mill soon comes to rest. Mill number 5 of the same company, but at a privilege lower down the stream, is often thrown into vibration by the falling water at that point, and the story is told that a watchman once fled from that mill, thinking that it was about to fall.

Of the eleven mills owned by this corporation, I have been told that none of the others vibrate from the above cause. When in operation, mill number 6 was often thrown into vibration by the motion of the machinery.

When vibrations are due to machinery, they are stopped by changing the speed.

At the Merrimac Mills, Lowell, and many other places, this method has been successful. It is unnecessary to cite further examples, but in all cases vibrations are noticed when some adequate cause is sounding the key-note; if the velocity of these pulsations is altered, the vibrations due to that identical cause will cease.

The consequence of mill vibration in the power absorbed by its exertion in the continual straining of machinery and mill must inevitably tend to damaging results to plant and product.

Were not a lot of columns placed almost at random out of the question in a mill, we could make the statement that vibration could be diminished and nearly stopped by placing columns under the principal centers of vibrations, and so dividing the floor into still smaller areas of vibration.

The only sure method of prevention applicable to the future seems to be in the construction of one-story mills, with the shafting resting upon piers in the basement. The result of the additional speed without any disturbance of stability, and of the diminution of the repairs under the same excessive conditions, in mills constructed upon the one-story plan, will hasten their introduction. In such a mill, if vibration should take place, it could be stopped by additional columns in the low basement without interfering with the machinery.

The swaying of a mill owing to oscillation is due to a lack of stability and weak construction, and the only correction possible for such cases is to increase the strength by reconstruction of the weak portions of the building.—*C. J. H. Woodbury, Manufacturers' Review.*

## SMOKE CONSUMER.

THE smoke which passes over the bridge of a Cornish or Lancashire boiler consists of carbureted hydrogen, which when united to a proper proportion of oxygen will burn at a certain degree of temperature. It is perfectly well known that the admission of a sufficient quantity of atmospheric air to the furnace of a steam boiler will cause the smoke to be consumed, but only at the expense of cooling down the flue that has been heated by the combustion of the fuel on the grate. In the smoke consumer which we illustrate herewith, the principle adopted is to thoroughly heat and dry the air, take out all the damp particles and rarefy the oxygen, and then mix it intimately with the smoke at the hottest part of the furnace. Fig. 1 of our engraving shows a vertical longitudinal section of Peyton's appliance, which includes the bridge, applied to the flue of a boiler; and Figs. 2 and 3 are perspective views of the back and front of the smoke-consumer, shown separately. The air taken from under the bars is admitted by a valve, which can be regulated by a rod according to the requirements of the furnace, when it enters the chamber and takes the course indicated by the arrows at the back of the bridge. Here it becomes raised in temperature to 500° Fahrenheit, and, thrown back from the fire-brick deflector, is made to impinge on the smoke and flame coming over the bridge, when perfect combustion ensues. The cast-iron plate at the back of the fire-brick bridge is corrugated so as to afford a larger surface for heating the air, and the plug shown at the bottom of the plate is for the removal of any incombustible particles that may have been carried over. This appliance is so strongly constructed of cast iron as to last as long as the boiler itself, and the fire bricks are not put in with mortar, so as to be easily replaced as often as required. The saving of fuel effected through the complete combustion of the smoke, the fact that this smoke consumer is self-acting and easily taken out to be refitted, and its durability, recommend it to the attention of steam users.—*Iron.*

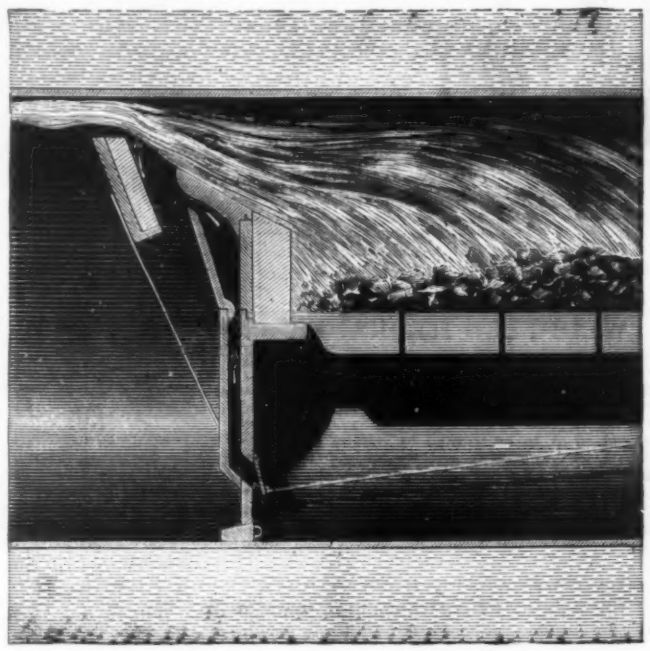


FIG. 1.

FIG. 2.

FIG. 3.

## SMOKE CONSUMING APPARATUS.

## NEW TEMPLE AT MOSCOW.

THE Khram Spasectelya, or Temple of our Saviour, at Moscow, is now rapidly approaching completion. The building was begun so far back as 1833, and was designed in commemoration of the French expulsion from Moscow. Nearly 4,000 laborers, for a month, were employed in digging out the ground for the foundations, and considerable energy was displayed in building the base; but, after a while operations languished, and the work has gone on by fits and starts, until it has now reached a stage when the architect can promise its completion next August, in readiness for the twenty-fifth anniversary of the Emperor's coronation. The height of the structure is 288 feet, and the style of architecture is the Russo-Byzantine, the building being in the form of a Greek cross, surmounted by five cupolas, one at each corner, and a large one, or dome in the center. The roof and the framework of the cupolas weigh 1800 tons, and the gilding on the latter has already consumed more than half a ton of gold leaf. Above the center cupola is a massive bronze cross, which can be seen from every part of Moscow. The bronze frames of the windows, each nine yards high, weigh nearly three tons, and the hinges of the bronze doors have to support five and one quarter tons of metal. Inside, the walls are gorgeously decorated in the usual style of Russian churches, and contain a number of jasper pillars, each of which cost upward of £2,000. The total cost of this wonderful building is estimated to exceed 20,000,000 rubles, or £2,500,000. But this is not all. Recently the architect reported that a block of houses in proximity to the temple was detrimental to one of the aspects, and, as a mere matter of course, the Synod voted £200,000 to demolish the buildings, and to construct in their place a terrace. It must not be forgotten that this is the second great cathedral which Russia has raised during the last sixty years, the famous one of St. Isaac's, in St. Petersburg, having been begun in 1819 and consecrated in 1858, after an expenditure of 36,000,000 rubles, or £4,500,000. A third cathedral, not quite so large, is also rising at Nijni Novgorod, and will involve an outlay of £2,000,000 before completion.—*The Parisian.*

## A NEW WERDERMANN ELECTRIC LAMP.

THE Werdermann electric lamp, which we have already illustrated, has recently been brought out in a new form at Paris by its inventor, and one which is a great improvement on the original model. In principle the Werdermann apparatus partakes of the nature both of an incandescent and of a voltaic arc lamp, and constitutes an intermediate system which ought to fulfill certain special conditions. In the new form illustrated herewith (Fig. 1.) the inventor has endeavored to regulate the pressure of the lateral contact on the carbon rod according to the pressure that the latter exerts on the upper disk. To this end the upper carbon disk is placed on a beam, the equilibrium of which is regulated by a screw weight. This beam carries a small arm placed in the interior of the globe, and which exerts on the movable lateral contact of the carbon a pressure which is so much the greater in proportion as that of the vertical carbon increases. This pressure retards the upward movement of the carbon rod. We have here, then, a sort of brake, the equilibrium of which depends on the way in which the regulation has been effected beforehand by means of the counterpoise. In measure as the carbon wastes away, the lateral contact loosens a little, and allows the carbon rod to move upward. In this arrangement, which permits of *very light contacts* between the rod and the disk, there is never any breaking of the point, but there is a regular wear, and consequently a great steadiness of the light.

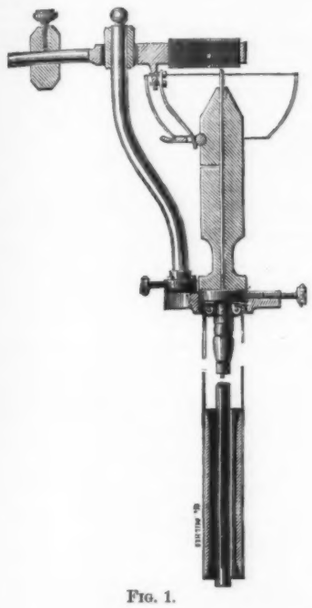


FIG. 1.

As several lamps are mounted in tension in the same circuit, if one of them should be extinguished it is necessary that it should be at once thrown out of the circuit to prevent the extinguishment of the rest. This result is obtained by the very lever which serves to press on the lateral contact. When the rod is no longer resting against the disk, the latter descends, and the lever strikes against a metallic catch, which establishes a direct communication, and throws the lamp out of the circuit. At a recent experiment at the Paris Opera House, twelve of these lamps, slightly modified for the occasion, were grouped on four lusters, and were supplied by two Gramme machines each having in its circuit six lamps mounted in tension. In the absence of photometric measurements it is at present absolutely impossible to give an opinion as to the economic value of the lamp under consideration, and unfortunately the want of just such data is too frequent at a time when with every invention is connected the question of dollars and cents. Mr. Werdermann proposes to apply his apparatus to domestic lighting. Fig. 2 represents a wall lamp, and Fig. 3 a hanging lamp, which show how the apparatus may be constructed for decorative purposes, although these particular forms leave much to be desired from an artistic point of view.

FIG. 2

FIG. 3.

## TELEGRAPH WIRES IN CITIES.

PRESIDENT GREEN, of the Western Union Telegraph Company, was recently asked to give a reporter for the *Sun* some account of the efforts that his company has made toward running telegraph wires underground in this city, and reducing the number of poles in the streets. Mr. Green, replying that the company had bought a half interest in the Brooks patent for laying wires underground in oil, and are about making the experiment between Newark and Trenton, referred the reporter to Mr. Robert D. Radcliffe, an expert, who has been making an examination in this city with a view to laying wires underground.

"In February last," Mr. Radcliffe said, "I began my work. I went to work systematically, and mapped out all the telegraph wires in this city. Then I went over the whole city, from the Battery to the Harlem River, and verified my map by actual observation, and finally, as a result of this work, produced this map, which shows at a glance my scheme."

Mr. Radcliffe unrolled on the floor a large map of New York.

"On this map," Mr. Radcliffe continued, "I have spotted the location of every telegraph instrument in the city, and the colors denote to which line they belong, whether Western Union, the Atlantic and Pacific, the Gold and Stock, the Police, the Fire Department, the Bell Telephonic, the American District, or what not, and from a study of this map I have perfected a plan of consolidating the lines of the city, which I think is entirely practicable. My plan is to have three great trunk lines running north and south—one through Third avenue, one through Sixth avenue, and another through Ninth avenue. From these trunk lines I would have branch lines east and west through every second street, the wires being taken from the trunk lines and conducted on poles to the place desired. I do not advocate laying these branch lines underground unless there are more than twenty of them in the same street, and I do not advocate laying the telephone wires underground, for the location of telephones is liable to constant changes. I found that under my plan, instead of 9,000 or 10,000 telegraph poles now standing, 1,500 or 1,600 poles will serve every instrument in the city in a complete and economical way.

"That the city has very many more poles than is necessary is easily explained. The first telegraph company organized placed its poles in the most advantageous position possible. As other companies came into existence they had to choose other routes, and as long as they were fighting each other there was no concession as to route. Since, however, the companies have consolidated, the three companies that I have spoken of have more poles than there is any need of. This plan is so simple that the Fire and Police Departments could use it. Some of the fire alarm boxes are not now in the proper position to be served from the trunk lines, but nine out of ten are, and the others could be easily changed.

"I was especially directed," Mr. Radcliffe went on to say, "to take into consideration the value of underground lines, the practicability of any of the systems, and the importance to the companies for whom I am working to maintain the present system of pole lines, in order to keep competitors from using them. I came to the conclusion that the interests of the city and the telegraph companies ought not to conflict, and that if anything was done by the companies to reduce the number of poles, the city ought to take means to prevent its ever again being incumbered by them, and I reported that I could see no advantage to the companies in keeping up their present lines at a great expense. I also advised that it might be well for the telegraph interests in the city to delegate to a separate company the work of maintaining the apparatus for carrying the wires, the capital of which should be furnished by the companies or by private parties, and the use of which apparatus should be rented to each company at so much a wire at a fixed schedule. This would enable the city and all the telegraph companies to avail themselves of this apparatus at fair prices.

"Now, a word about the proposed trunk lines. Naturally, the first thing to do was to ascertain the necessary capacity required, allowing for the growth of the telegraphic business in the city. I first ascertained how many wires there would be in each division of the trunk lines on the present basis of business done, and after considerable hard work, as you can imagine, I found that the greatest number of wires that would have to be conducted through one trunk line is 841; and they would run across Broadway, from the main building of the Western Union, at Broadway and Dey street, and down John street. Of these 841 wires, 583 will go down town to the great commercial centers, and 258 go up town on the east side, decreasing in number, of course, as wires are led out to the side streets, until the trunk line reaches the Harlem bridge at 130th street, with only 49 wires. The route of this trunk line would be down John to Pearl street, and thence up town, following the line of the elevated railroad. The 583 wires that run down town would be conducted by a series of underground trunks, terminating at the Produce Exchange on Pearl and Whitehall streets, with 72 wires.

"The center and western trunk lines would start together at the main building, with 330 wires, and run down Dey to Church street, where 190 wires would turn up Church street and follow the line of the Metropolitan Elevated road to 53d street. The other 140 wires would continue down Dey to Greenwich street, and then turn up town, following the route of the west-side elevated road. At 53d street the center trunk line will have only twelve wires. These I would run across to the west-side trunk, which at 53d street will contain 57 wires. These 69 wires will then be conducted up town on the west side to 125th street, where the trunk will contain only fifteen wires, which there leave the trunk and follow the line of the Hudson River Railroad north.

"Many of the wires of the west trunk leave it at 55th street and cross the Hudson river in cables, and then go to the lines of the different railroads.

"Below John street and on the east side of Broadway there are more instruments than in any other part of the town, but they cannot be reached by the same system of trunk lines and branches that can be used up town. That whole territory must be covered by underground systems, and the proper disposition of the lines has given me much trouble, but I think I have solved the problem."

Mr. Radcliffe, on his map, traced the devious windings of the lines that run through the great business center of the city. He continued:

"My next work was to estimate for the probable increase in business. My data were ascertained several months ago. There were then in this city 1,148¼ miles of Western Union wires; 290⅞ miles of Atlantic and Pacific wires; the Gold and Stock Company had in their stock interest department 151 miles, and in their private line department 1,330 miles; the Bell Telephone Company about 500 miles; American District Telegraph Company 300 miles; Fire Department 702 miles, Police Department 90 miles; Law Telegraph over 100 miles, and American Union about thirty miles—making in all 4,663⅝ miles of wire in New York city.

"I find that the Western Union and Atlantic and Pacific Companies, the companies that do a commercial business, have not increased their mileage more than twenty per cent. in the past two or three years, and that the local companies are increasing their mileage very rapidly. For instance, the American District Telegraph Company, started in 1872, has placed 300 miles of wire in seven years, and is growing at an increasing ratio yearly. The Bell Telephone Company placed its first telephone in September, 1878, and at the end of another year will have added, at their present ratio of increase, 1,000 miles more to their 500 miles. The growth of the private department of the Gold and Stock Company is at the rate of 40 miles a month now. Judging from these data, I conclude that the trunk lines ought to have a capacity of 1,000 wires each to meet the demand that the increase in the telegraphic business is going to make in the coming ten years.

"Now," the expert continued, "with the knowledge of the requirements of the trunk lines, I have examined the merits of the different underground systems to ascertain whether they were adapted to so large a capacity in any one street. Most of them I find inadequate. The Brooks system, the invention of David Brooks, of Philadelphia, admits of the treatment of a very large number of wires in a small space. It consists of covering small copper wire with cheap cotton wicking, and grouping them into cables of twenty or fifty wires, and drawing these cables into 1¾ inch iron pipes, which are then filled with paraffine oil. This method has the merit of cheapness in the treatment of individual wires, and the grouping of a large number in small compass, which makes the cost, as applied to the whole, comparatively light.

"The *sine qua non* in any system is that it shall permit of the wires being drawn out and manipulated at the will of the companies, without disturbing the pavement. The Brooks system and the English system I found to be the only ones permitting this. The latter, which is in very general use in London and in the English postal telegraph service, consists of wires insulated in gutta percha and laid in pipes, with draw boxes at various intervals. The top of these boxes is near the surface of the street, and workmen, in handling the wire, must work on the street. This of course, is a great objection, and in this system it requires four or six hours to mend an ordinary broken wire. An American inventor has made an improvement on the English system, by deepening the draw boxes and enlarging them into small vaults large enough for one or two men to work in. Then the wires could be handled underground. This is a great improvement, for it does away with the working on the surface amid a moving throng, and by it a wire can be mended in three or four minutes instead of as many hours. But there is great difficulty in applying the Brooks system to the vaults, because, since oil is used, of course the pipes must run continuously through the vaults, and they would take up so much room that there would be no opportunity for men to work. I have an idea which I think is practicable. It is to use stoneware or cement conduits in which to carry the cables. I would have them made not as one large tube, but a group of tubes, six or eight, or whatever number was needed. You will understand when I say a reduced cross section of one of these conduits would resemble in a measure the muzzle of a Gatling gun or an old-fashioned pepper-box pistol. I would have a vault four feet square at every second cross street, each vault connected by these conduits. Then the wires which run through the tubes of the conduit would be separated at the end of each conduit and run to switch-boards on the sides of the vault, and from the switch-boards on to the next conduit, where they unite again. Of course the wires would be insulated. When a break occurred all that would be necessary would be for workmen to go into the two vaults between which the faulty wire ran, unscrew each end of this wire from the switch-board, and either mend it or replace it with a new wire, as the case required. The conduits can be made so tight as to remain dry, and thus the insulation would not suffer from moisture, its greatest enemy. At these vaults the wires for the cross street could be brought up through an iron tube to the cross-arm of the pole, and thence led to its destination.

"I examined the streets to ascertain whether such a system of conduits could be laid. I find it could, but there are many difficulties. For instance, in Third avenue, for a long distance there are twelve different lines of water and gas mains, in addition to the foundations of the Elevated road. I took into account the difficulties, and came to the conclusion that for the uses and purposes of the telegraph interests in this city, the superstructure of the Elevated railroad offers the cheapest facilities for carrying the trunk lines. My plan would be to have troughs of galvanized iron, with movable covers, placed on the girders of the road outside of the track.

A trough six inches square would hold the 1,000 wires necessary, which might be laid in singly or in small cables as the needs of the companies demanded. At every second street this trough would enter a small wooden box or cable house, where the joints in the wire could be made, and any wire needed brought out direct to the top of a pole standing on the corner of this street. One objection to this may arise from a disposition on the part of the owners of the Elevated roads to exaggerate the value of this privilege to the telegraph companies. The actual worth to the companies would be the interest on what it would cost to open a trench in the street. This interest would amount to about $70 a mile. It would be an objection to be dependent upon the will of the roads. Then a fire might seriously damage the line, or a break down in the road. Undoubtedly the best plan, aside from its cheapness, is an underground system, and I think the earthenware conduits, with switch-boards in the vaults, the best of the underground plans.

"I have made some estimates as to the cost of the various plans proposed. My estimate of the cost of the Brooks system in New York, for the three companies, including wire to meet the present wants, with a possible expansion of twenty per cent., is $258,281.34. This has reference to the three trunk lines only. Without taking into consideration the cost of wire, the lines would cost $133,591. The English system, without wire, would cost $137,148.53. This provides for building trunks simply, leaving the companies to put in their wires as they need them. The trough on the elevated roads, independent of the rental, would cost $49,444.50. I have not completed my estimates on the stoneware conduits, but the pipes themselves will cost one-quarter less than the Brooks system pipes.

"I believe that the city must in some way get rid of telegraph poles. I have spoken of using them on the cross

streets. I would only so long as the wires were few in number. When they reached twenty I would put the wires underground, and in time, I believe, New York will be comparatively free of telegraph poles."

## A NEW PHONOGRAPH.

THE Edison phonograph, as shown in 1878, has remained the same up to the present time. This interesting invention, however, was not perfect, for:

1st. Its capacity of registry is limited by the dimensions of the cylinder.

2d. The necessity of raising the impressed sheet destroys the perfection of the embossing.

3d. The tin foil used is incapable, by reason of its malleability, of reproducing the sounds given it, save to a very limited extent.

A young professor of the Polytechnic Association, M. Gustave Gamard, has overcome these objections, and we are pleased (says the *Correspondance Scientifique*) to be the first to give the results to the scientific world. Modifying completely the form of the American phonograph, M. Gamard has substituted rectilinear for curvilinear motion.

His apparatus consists of a platform, upon which may be placed a series of traveling frames, made to traverse horizontally by means of a crank and toothed wheels. In the centers of these frames is fastened, either permanently or temporarily, a thin sheet of silver or copper. Above this sheet of foil is placed the vibrating diaphragm with its needle point. Successive frames are caused to pass under the vibrating plate, until the required speech or conversation is completed.

M. Gamard overcomes the second objection to the Edison phonograph by disengaging the foil without injury from the traveling frames, and replacing this as required; and the substitution of copper or silver for tin gives at the same time a more lasting impression, as well as a clearer registry of the vibrations. The use of rigid foils like those mentioned would be impossible upon a cylinder, while with this new application nothing is more easy.

These happy conceptions of M. Gamard seem to us of a nature to hasten the rise of the phonograph from the idle domain of curiosity to the busy fields of practical life.

## RECENT WONDERS OF SOUND.

A recent lecture before the Society of Arts, London, by W. H. PREECE.

I HAVE not brought you together to astonish you with new inventions, or to excite your wonderment at some of the advances that have been made of recent years. My principal object is to let every boy and girl who has honored me with his or her presence this evening see the advantages to be gained by knowing how to use his or her eyes and hands.

All advances of science are the result of experiment, and experiment is the simple mode by which new facts are brought to our knowledge. A great physician, some hundred years ago or more, lived in the town of Derby, and he was the grandfather of a very great man who lives now, Mr. Charles Darwin. This old doctor said that "a fool is a man who never tried an experiment in his life." I am quite sure that there is scarcely a boy in this room who does not, every day of his life, try an experiment of some kind or the other, and therefore there is no fool among my hearers. Every boy has, at some time or other, taken a paper bag, such as the one in my hand, and after blowing it out has burst it between his hands, with the view of startling his little sister or raising a smile from the cook. When he has done this, he has performed an experiment; but it is one thing to experiment, and another thing to draw a lesson from such experiment; and it is toward the endeavor to exercise your thought, by carrying your minds from the natural effect to its cause, that I am more anxious to lead you than to anything else. For instance, every boy, as I say, has made an experiment; but has any one asked himself why it is that clapping one's hands, blowing a whistle, or making a sound in this way (bursting the bag), produces the effect on the brain that is called sound? When the bag is blown out to its full size, and forcibly compressed, there is a condensation of air in it; and then, by the bursting of the bag, an expansion; and by this sudden expansion, a disturbance of the air about us is produced, which has resulted in something being done between you and me. If I take this popgun and force down the handle rapidly, you hear by the report I have produced a disturbance in the air. Between the popgun and every ear in this room there has been a sudden vibration produced. We all know that, when a clap of thunder is heard, the windows shake; when, in church, the deep notes of the organ are sounded, one can feel the pew vibrate; and those of you who in future years may travel to such places as the Falls of Niagara, will find that in the neighborhood of the enormous roar of this water there is heard an incessant and constant vibration of doors and window sashes. Hence, when we have sound, we must have as a source of production a sudden disturbance of air. There must be a medium to convey these vibrations, and that medium is the air itself. To appreciate sound or know when it is produced, there is something to receive it, and that medium is the organ of the ear. It follows then that sound and vibration are concomitant, or similar things. To convey these vibrations to the ear, they are received by the air in which we live and move and have our being. This air forms an enormous ocean 50 miles deep, and we are nothing but crabs and lobsters crawling at the bottom of it. This air swathes our bodies, and, when it is thrown into vibration, it affects our ears, and this effect is what is called sound. What is this air? We cannot see it. We sometimes feel it, especially latterly, during the heavy gales of wind that have prevailed. Birds fly in it. It maintains the lights before us burning, and keeps us alive. We know that this air is composed of atoms and molecules. We will take no notice of the atoms, but will fix our minds on the molecules or clusters of atoms of which the air is composed. This room is the receptacle of more millions upon millions of these molecules than I could count if I were to keep on till to-morrow morning. Every little molecule of air is thrown into motion when sounds are produced, and every motion I make with my lips, and every sound I utter by such motion, strikes your ears, and produces the sound of my voice. To give you an idea how this is done, I have upon this board arranged a series or row of marbles. I have no doubt most of you are acquainted with that highly scientific apparatus, a marble, and have frequently experimented with it in various ways. That row of marbles represents a row of the molecules of air that exist between my mouth and your ears; and when I take a marble from the right hand end of the row, and let it fall back into its position again, you will see that almost instantaneously the marble at the end of the left hand side of the row leaves its position for a distance and falls back again. If I take two marbles from the right hand and let them fall back, you will notice that two at the left hand are driven off, and so on. So with the molecules of air. Every time I utter a sound the molecules near my mouth are disturbed, and a similar disturbance takes place in your ear. You will see that the action through the row of marbles takes very little time indeed, but with the molecules of air the time taken to produce these movements is perfectly well known, and the movements are easily measured. The velocity or time that a sound takes to travel through the air is about 1,100 feet per second. I say "about," because it varies with the temperature. On those bright, brisk days, a short time ago, when we all enjoyed our skating, sound traveled at the rate of about 1,000 feet per second. On those hot, muggy, uncomfortable days, like yesterday, sound traveled about 1,100 feet per second. In water sound travels very much quicker, being at the rate of 5,000 feet a second. With wood it is quicker still, being about 16,000 feet per second. So that the velocity with which sound passes through different media is simply dependent upon the character of the medium and the ease with which the molecules composing it transmit each other's motion. Bearing in mind the fact that sound travels at the rate of 1,100 feet per second, you can all try an experiment the next time you hear thunder. Lightning travels at a rate which is practically infinite; it is in reality 186,000 miles a second, but it is so fast that you may regard it as instantaneous, and, therefore, the moment you see the flash, you know it has just taken place. Sound, traveling at the rate of 1,100 feet per second, takes about 4½ seconds to travel a mile. So that, having seen the flash, if you count 1, 2, 3, 4, 5, and so on (representing seconds) till you hear the thunder, then if it occurs on your counting five, you know that the storm is a mile away, and you can put your head beneath the clothes and be perfectly easy. If, on the other hand, you see the lightning, and the crash follows immediately after, it is very near. But there is one thing very certain, that, having heard the crash, you are all right, for the lightning which caused it has passed away. The speed with which sound travels is the cause of having such things as echoes. Echoes are simply due to the reflection of sound. From the far end of the room every sound I utter is reflected back to me, but because the distance is so short, I do not hear any difference between one syllable and another. But if the wall were 1,100 feet away, or rather half that distance, then at the end of each second I should get back the sound that I utter. Hence it happens that in large halls it is extremely difficult to speak, because the echoes are so confusing. In the Albert Hall, for instance, there is a certain spot on the platform where poor unfortunate speakers stand, and, unless they are up to the secret, they get confused in a series of sounds coming from all parts of the building. But when a speaker there knows what to expect, he regulates his voice, and the echo becomes a guide to him how to send his voice right away up to the ceiling. When I had the pleasure of lecturing there, I heard back every word that I uttered, and waited for it before I gave out a second, and the result was that I succeeded in filling the large area with my voice, though it is naturally not a very strong one.

The motion of these particles through the air is in itself an interesting study, but they are very complicated in their action. The nearest approach to the motion that I know of, to give you a mental picture of what takes place in the air, is the swaying of a field of barley. Many of you will remember how the gentle breezes blow the tips of the barley in extremely pretty waves, and the formation which these tips take is almost identically the same form which the molecules of air take when transmitting sounds. In fact, if it were possible to suddenly illuminate this room, and to enable you to see the condition of the molecules of the air, you would see them very much as you see the top of a field of barley, excepting that, as the molecules are so small, you would require an infinitely powerful microscope to see them, whereas in the case of fields of barley you can exercise your own eyes.

Sounds are produced by the sudden expansion of air. Sounds being transmitted by this wonderful material, air, we want something to receive the impacts—the movements—of these little molecules, and that is given to us by the ear. On the wall to my right you will see a diagram representing a section of the human ear. Here is the outside of the ear, the shape of which we all know so well. Then there is the inner tubing, and a little way inside this tubing is what we call the drum of the ear. This drum is, in fact, a membrane or disk (a small-sized drumhead), which is hit by the molecules every time they are disturbed by the utterance of sound. The character or nature of the sound is simply dependent upon the way in which it is struck by these little molecules. There is a wonderful and beautiful system of bones that takes up these sounds again from the drum of the ear, and transmits them to the nervous system, and then to the brain, but we have not to-night to trouble ourselves with what takes place beyond the drum of the ear itself, nor should I attempt to show you, for one very good reason, that I do not know myself, and I do not think that anybody has yet attempted to solve the mystery, how it is that the motion of the molecules of the air is transmitted to the brain.

If anybody is anxious to know what sound is, there is a very simple experiment that you can all try. If I put my watch to my ear I hear the ticking of the watch through those molecules hitting the drum of my ear. If I place the watch in my mouth, so as not to let the teeth touch it, I hear nothing; but if I bite the watch, then the ticking comes out as clearly as when the watch is placed close to the drum of the ear; and in this instance the sound is transmitted to the brain, not through the drum of the ear, but through those complicated bones that support the drum and form part and parcel of the organ of hearing.

We have now to talk about the character of sound. We have seen how it is produced. We have seen how it is transmitted and how received. Here is a box which I will shake, and you hear a sound which, I dare say, many of you will think represents the familiar sound of your money box, but it is caused by nails. Here is a box containing a different arrangement to nails, and you will recognize it as an accordion, from which I can draw forth sound in the shape of music, though I am not player enough to give you a tune. Another sound pleasant to the ear may be produced (as you see I now do) by ringing glasses on your dessert table; you can take your finger-glass and just rub it round the edge, and a very sweet sound is at once heard. I have myself seen a man in the street playing on an arrangement of glasses in this manner with the most beautiful effect. From these illustrations we see, therefore, that sound can be divided into noise and music. But music itself possesses very distinct and separate qualities, and I want particularly to impress upon you these different qualities of sound, because upon them depends your knowledge of the instruments that I am going to bring before you.

First of all, the difference in "pitch" of a note is produced by the number of times that the molecules hit the ear in a given time. Here I have a tuning fork which is so constructed that it wags backward and forward 256 times every second, and consequently it sets the molecules of the air in motion between it and you, and you get a beat on the drum of your ear 256 times every second, and these beats represent the sound known as "do." Here is another tuning fork representing "mi," which beats 320 times every second. Here is "sol," which will disturb the drum of your ear very fiercely 384 times a second. Here is our friend "do" an octave higher, that hits you 512 times a second. In order to show you a little more clearly that these effects are produced, we have here a disk that has a series of holes pierced through it, and I have an India-rubber tube through which I can blow; but blow as I will, you do not hear any sound. If I allow my breath, as it makes its exit through the tube, to pass through the holes in the disk as it revolves, my breath is broken up into a series of pulsations or blows, so that again you get your ears hit with the proper number and rate to produce notes. [The disk is known as the siren, and the "scale" was played once or twice both slowly and rapidly upon it.]

Here is a little contrivance in which, instead of exerting my own lungs, I can bring an artificial pair of bellows into play, the air from which causes a little disk to rotate; and the higher the speed at which this disk rotates (by continuing the pressure of the bellows) the higher the pitch; and by pressing the bellows slower and slower, the note becomes lower. Here is another instrument that shows you the same effect as the one just exhibited; and I want you to thoroughly understand this fact, because it lies at the root of all our microphones and telephones, and therefore it is an essential thing that you should grasp and see for yourselves, with your own eyes, not merely the eyes of your body, but the eyes of your mind, these wonderful things that take place to produce sound. This is simply a little iron disk which I bring into contact with the edge of a toothed wheel. When the wheel is turned, you hear sound produced. As the velocity is increased the pitch of the sound is higher and higher till you hear a perfect shriek; then, on the speed coming down, the pitch becomes lower. You will understand by these illustrations that the pitch of a note depends upon the number of times the drum of your ear is hit by the molecules of air. But I can do more: I can almost make you see the sound. Here is an instrument that is called a phonoscope, and it is the invention of a gentleman named Edmunds. Here we have a glass tube that has been exhausted of air and supplied with gas. We send through that tube currents of electricity, and Mr. Ladd will sing, cough, laugh, etc., and you see a flash of light in the tube for every note. This is an ocular demonstration of the fact that every vibration of the disk produces the effect that leads to sound.

It is worth noticing that the lowest note which can be heard by the human ear is produced by vibrations of 16 to the second—the highest is produced by 38,000 vibrations to the second; so that the human ear has a limit between 16 blows per second and 38,000 blows or vibrations per second. But the human voice itself is only capable of producing vibrations between 65 per second and 1,044 per second; and the highest double C of some of our chief sopranos only means a little more than a thousand vibrations per second. But yet the ear can detect sounds higher than that of the highest voice. There are some ears that can hear the bats cry; there are some that cannot.

There is a very interesting inquiry being carried on just now by Sir John Lubbock, on the habits and manners of ants; and that gentleman has shown beyond question that ants have a mode of communicating their ideas to each other. An ant strolling about may come across a piece of meat, and he will hurry back and say something to the first chap he meets, and they will go together to the meat and will carry it to their nest. The results of Sir John Lubbock's watching of the habits of these little fellows are most wonderful. We are quite sure they talk or have some mode of conveying their ideas; but if it is by sound, the number of vibrations are so excessive that the human ear cannot detect them. The microphone and all kinds of contrivances have been tried to ascertain if they converse, but, so far, it has all been of no use. We have even gone so far as to make a special little instrument that will vibrate nearly 200,000 times a second, but still the little rascals have defied the investigation. There is yet a hope that, by perseverance and observation with special instruments, Sir John may one day find them out, even if not be able to convey their ideas to us.

The first fact that I brought to your notice is that sound varies in pitch. The second quality in which it varies is, that of loudness; and loudness is produced either by the increase of amplitude that is given to the motion of these molecules, or to the quantity of air that we throw in motion. For instance, if I take a small tuning fork and hold it up in the air, you do not hear; but if I take a longer fork, you, perhaps, hear it because its vibrations are greater and it causes a greater amplitude or spreading out of the waves of air. But if I take a little contrivance I have here to increase the quantity of air thrown in motion, you can hear. This is done by placing the tuning fork on a small piece of wood extending from the apex of a paper cone. So if I take a larger surface, a larger paper cone, there is a louder sound, as you can hear. If I take a still larger fork and hit it upon the table, and hold it in the air, you hear the sound without the aid of a magnifier, as I may term it; there is a considerable difference in the loudness of the tone, owing to the greater quantity of the air that is thrown into motion. We can also increase the loudness by taking a conical shaped roll, and speaking into it at the smaller end. It is by taking advantage of this fact that this elegant and scientific apparatus, known as a speaking trumpet, has been utilized for carrying orders to different parts of a ship.

The next point connected with sound that I want to call your attention to is its quality. You are all acquainted with this extremely beautiful musical instrument in my hand. Perhaps some of you may think it is an expensive flute, but, between ourselves, I am bound to tell you that I paid a penny for it; and, though modest in price, good music may be got out of it. Here is another musical instrument—a fiddle; and if I were Paganini or one of those three fellows who played before "Old King Cole," I could give you some good music, but as it is the first time I have handled a fiddle, I will only just touch it that you may hear the kind of sound it produces. I am playing the note C on this fiddle. I now take the whistle and blow the note C, and so on I may go through all the musical instruments—cornet, clarinet, accordion, jewsharp, etc., and sound C;

and although each instrument will strike your ears exactly the same number of times per second to produce the note C, nevertheless the notes differ very much in the particular form that distinguishes one instrument from the other. This quality is due, not to the number of times that your ear is struck—not to the strength of the blow, but to the form in which it is struck. Here is a little instrument by which I hope to show you what I mean. It is a spring with a silver bead on the top. The silver bead reflects, as you see, a spot of light. You will see that when I move the bead straight up and down, or to and fro sideways, a line of light only is reflected; but when I vibrate it, and move it toward you, the most beautiful waves are reflected. The human voice is one of the finest musical voices ever constructed; in it you have all the beautiful tones of music. But you never find two voices sound alike; you never hear a man speak twice in exactly the same way; and the result is that the human voice differs very much more than any other form of apparatus, but it does so simply because of the construction of the mouth, the size of the tongue, the formation of the teeth, and the way in which one breathes at the time air is taken into the lungs. Any slight difference in these things varies the form of the air when it passes from the mouth of the speaker to the ear of the listener. I will illustrate this by my jewsharp. If I place the harp in my mouth, and shape my mouth for the sound "O" to be given out, on striking the harp you hear that sound given; if I alter the shape of my mouth, "A" is given, and so on.

We have spoken of sound varying in pitch, loudness, and quality. We have now to speak of the impression of sound. We want to impress the sound on something. If any of you, when at home, will take the trouble to open the top of the piano, particularly if a grand piano, and press down the soft pedal, and sound on the middle note the vowels *a o e*, you will find these vowels come back to you perfectly distinct. You all must have noticed that when any one sings to a piano there are certain notes that always vibrate in sympathy to the human voice, and sounds are heard back again. It has been said that Lablache, one of the greatest deep bass singers we ever had, was able to sing a note so loud that he could crack a tumbler, and did actually break one before his audience.

To illustrate this impression of sound I must borrow a hat. Here is a hat, to the crown of which I will fix a little apparatus, consisting of a spring, which when it vibrates makes contact in a telegraphic circuit, in which two telephones are fixed at the far end of the room. The spring vibrates when the crown of the hat vibrates, and if I speak into the hat the sounds are given off by the telephones. [The audience near the telephones recognized the sounds.] The crown of a hat is not essentially necessary to show you this. A disk of thin iron, ebonite, or parchment, about three inches in diameter, will, under the influence of my voice, vibrate in the same way; and I want to show you that they not only vibrate in this manner, but they do so just the number of times required to make the note spoken, just the amplitude required to produce loudness, and just in the form required to produce quality. My friend Mr. Stroh (to whom I am so much indebted each time I have had the pleasure of being here) has made one of the most beautiful apparatus that I know of to illustrate this point, and he has kindly brought it to illustrate my lecture. It is a phonoscope. We have a magic-lantern, in front of which is a thin disk, upon which there is a mirror which reflects a spot of light on the screen on the wall, and it is to the movements of that reflected spot of light that I want to call your attention.

[The gas was then turned down, and Mr. Stroh caused the spot of light to rotate rapidly, forming an unbroken ring of light on the screen. He then spoke the vowels to the disk, and each vowel caused its representative variation in the edge of the circle of light. Coughs, laughing, etc., also were shown to break up the rim into greater or less zigzag projections.]

There you have a perfect representation of all the different qualities and properties of sound. I want now to speak of the transmission of sound, and I must claim your indulgence, for the time is going very fast, and I cannot dwell on the experiments. You are all familiar with speaking tubes as used at the present day, for conveying orders from room to room in the house, hotel, or office. The ancients employed speaking tubes in connection with their idols, and used sometimes to make their oracles tell the most wonderful stories. The gentleman whom I mentioned in the opening of my lecture, Dr. Erasmus Darwin, was one of the first in England to construct a speaking tube. He fixed it between his dining-room and his kitchen—very near the fireplace in the latter. A patient sent his servant one night to the doctor for assistance, and while the man was sitting by the fire in the kitchen waiting for his message, he heard a sepulchral voice, coming apparently from the fire, say, "I want some coals," and he jumped up and ran away, and told all the neighborhood that Dr. Darwin was a magician. We have a mode of producing and transmitting sound that is due to the late Sir Charles Wheatstone. Between a room down-stairs and here is this deal rod, which is resting upon a musical box. As it is, you hear nothing at all; but if I take this butler's tray and place it on the deal rod, you hear the musical-box playing, which disappears on my taking off the tray, and reappears on my again placing it on the rod. It is a good experiment; but I must pass on, as it is difficult to keep pace with time, which, as you know, waits for nobody. This is one of the first forms of telephone, invented as far back as 1819. The sound is reproduced in that case only from the room below. We are now going a little further, and will transmit and reproduce sound from the city. Between this room and the city there is a telegraph wire, and on that wire telephones have been fixed. There are numerous forms of telephones. The diagrams on the wall will give you some idea of what they are. I have shown you Wheatstone's mechanical telephone. There is a form of string telephone that you are all, I have no doubt, acquainted with, and a very beautiful scientific apparatus it is, and one through which conversation can be carried on for a considerable distance. But Professor Bell, in 1876, formed an instrument by which sound could be reproduced at a much greater distance than by any means previously known. Reiss, a German schoolmaster, in the year 1860, had done precisely what I showed you with the hat; and in fact I ought to have told you that the hat arrangement was nothing but a Reiss telephone. But Bell went very much further than Reiss. He was able to reproduce speech, and the electric signals coming through the wire coming into this room from the city are transmitted with just the amplitude and form that I showed you on the disk, and they reproduce all the qualities of sound, either of musical instruments or the human voice.

Still further improving on what had been done before, Professor Hughes invented the microphone, an instrument by which the motions of the air, the sonorous vibrations as they are called, act directly on a portion of the electric circuit, and vary the electric currents in all their beautiful waves. The instrument which I have before me is one of Mr. Louis Crossley's (of Halifax). It is a form of transmitter, based on Professor Hughes' discovery, and the arrangement between this room and the city is just what you see on this diagram. We now ask the man in the city to say a few words—and there you hear what he says. His voice in the city is setting electric currents flowing which produce vibrations in the air. The sonorous vibrations in the city impinge on a disk, just as those of my voice did on the hat; that disk produces currents of electricity, which vary in number, form, and quality. These currents of electricity traverse the telegraph wire between the two rooms, and are received on the instrument here by a little magnet, and this magnet causes the disk at this end to vibrate just in the same way as the disk vibrates in the city. I repeat, then, that what a telephone does is this: A disk is thrown into vibration by your voice, just as you saw Mr. Stroh's phonoscope thrown into vibration. These vibrations are transformed into currents of electricity, which come to this distant station and here cause another disk to vibrate in exactly the same way, and throw the air of this room into similar vibrations, as the air is vibrated in the room in the city, and the effect is that we hear apparently the voice of the man at the sending place. If wires were clear, that is, free from what is called induction, distance would be practically of no consequence. I have spoken between Holyhead and Dublin in the same way that I am speaking to you. I was in Holyhead, my friend in Dublin, and I talked so nicely that he actually told me that he could smell my cigar. In America they have talked through a greater distance. There was an account in the paper the other day of a conversation being held at a distance of 2,000 miles. In fact, Professor Bell and myself spoke through "resistance," as it is called, that represented 10,000 miles, and the wire through which we talked was within itself really a telegraph 10,000 miles long. There is no doubt whatever that, if we had a telephone or a wire from here to the moon, and if any of you were to follow Jules Verne's hero and go to the moon, we should be sure to talk comfortably, and without the slightest difficulty.

I want now to say one word about talking machines. There are many such. There is Faber's, which was introduced in England in 1843, and is now in England, but not on public show. We can all make talking machines for ourselves if we like. Here is a penny trumpet. If I close the end with my hand, and, on blowing through the tube, imitate the motion of the lips with my hand, I can make it sound "ma-ma." Not a very good one perhaps, but, nevertheless, it shows you that, by the proper manipulation of India-rubber tongues and lips, or things of that kind, it is possible to construct a machine to emit sounds representing speech; but Mr. Edison has far transcended anybody else, and by taking advantage of this power that we have of making disks represent in pitch, in loudness, and in quality, the sonorous vibrations, he has been able to reproduce the human voice with wonderful exactitude by the phonograph. Here is a phonograph or talking machine. Its construction is illustrated by the diagram on the wall. The diagram is not exactly a representation of the particular one before you, which is regulated by clockwork. You will notice the disk into which words are spoken. Here is a cylinder upon which lead foil is fixed, and when I speak into that disk I cause it to vibrate. The vibrations cause a little point to impinge on the lead. On this lead dots, and ruts, and waves, and curious marks are made; and when these marks are caused to go a second time over the same ground with the disk in contact with or again pressing on them, they reproduce the sounds first spoken. [Several sentences were spoken into the phonograph, and the sounds of coughing and laughing were sent into it, and came out again clearly.]

We have the pleasure this evening of having among us a gentleman who has recently returned from the Cape, and whose name in that part of the world is a household word. I mean Sir Theophilus Shepstone. He can speak Zulu; and I have no doubt that many of you will be glad to hear the sound of the Zulu language. But we are also anxious to know if the phonograph itself will reproduce the Zulu tongue, because in the Zulu and Kaffir languages there are sounds we do not know on this side of the globe—curious clicks. [Sir Theophilus Shepstone spoke a few sentences in Zulu to the phonograph, which he said repeated the words very faithfully.] I am indebted to you all for your very kind attention to-night to what I have said. I have led you up from the mere elements of sound, from sonorous vibrations to the way in which you may "waft a sigh from Indus to the Pole;" and to the mode by which we can even reproduce voices that are still. But although there are wonders, and recent wonders of sound, I do not want you to forget that they are the outcome of experience, and the wish that I have in giving this short course of lectures is simply to induce boys and girls to use their eyes and hands in observation and experiment.

## MAGNETIC REACTIONS.

By TH. DU MONCEL.

THE effects of magnetism, as they are usually pointed out, are far from agreeing with those which practice is revealing at every moment; and, owing to the often inexact data that are possessed, it sometimes happens that we meet with deception only in the results expected. The reason is that two magnetic actions which are essentially different are confounded with each other—*static action*, that is, the action revealed by magnetic attraction, and *dynamic action*, which gives rise to the reciprocal mechanical reactions of magnets and currents. These two actions are not mutually dependent on each other, although they may have a reciprocal influence, and consequently may be *independent*. *Dynamic action* is induced by those magnetic currents which Ampère supposed to envelop the magnet throughout its whole extent and perpendicular to its axis, and may be considered as dependent upon a resultant applied to the center of the magnetized bar. This resultant, then, represents all the individual actions of the currents constituting the magnetic helix. From this point of view the magnetic action is found to be most energetic, exactly according to the neutral line, where, however, no action of attraction takes place. In fact, it is at this point that the effects of induction are most energetic, and this is why MM. Poggendorf, Muller, Fabre, and others have advised the rolling of the helices of the induction coil like a spindle. It is for this reason, too, that when a small induction coil is caused to revolve on a magnetized bar, the resulting induced currents are direct when the coil moves from the neutral line, and inverse when they approach it. *Static* action, on the contrary, closely approximates to that of the electricity by induction, which is in play in electrical condensers. Without in any way entering into the theory of the molecular effects which may then be produced, it may be said that, under the influence of the polarities that are developed at the two extremities of a magnetized bar, there is determined, in the presence of a magnetic body such as iron, a peculiar arrangement of the magnetic atoms, which, without altering the motion of the peculiar currents of Ampère, has the effect of exercising at a distance an action by induction, analogous to that of static electricity, and of constituting around the magnet what is known as a *magnetic field*, and in which all magnetic substances become polarized according to the known laws of electric attraction and repulsion; and from this result the effects of attraction with which we are acquainted. In a magnet these static effects have two centers of action which form what are called the *poles of the magnet;* and these poles are, as we know, situated near its extremities. It is the middle portion which is found to be in a neutral state, and consequently without action, regarded from the standpoint of the actions which we are now studying. If the two actions which we have just analyzed can act independently of each other to attract iron, and can produce induction currents, they can nevertheless reciprocally influence one another. So a magnet surrounded by an induction coil, which will furnish currents of opposite natures, will, whenever it is magnetized and demagnetized, give *rise to currents which are infinitely more energetic if a static reaction intervenes; i. e.*, if its two extremities be provided with two iron armatures; and this proves that, in this case, static reaction has strengthened the magnetic power of the magnet. This action then is effected after the manner of that which is developed in a condenser, and we shall soon see how the phenomenon may be produced.

On another hand, if the static reaction is such that it modifies the magnetic polarities of the magnet, or of a system composed of a magnet and an iron armature, dynamic action is not for that reason disturbed; and, although at the point where a neutral line should be found, we discover a perfectly characterized magnetic polarity. The induced currents which are then produced demonstrate that, from a dynamic point of view, the system is regularly constituted. But in order that we may be able to understand all these effects, it is essential that we should first study the manner in which static magnetism is distributed in a simple magnetic system or in one combined with an armature. Figure 1 represents the *magnetic phantom* of a regularly constructed

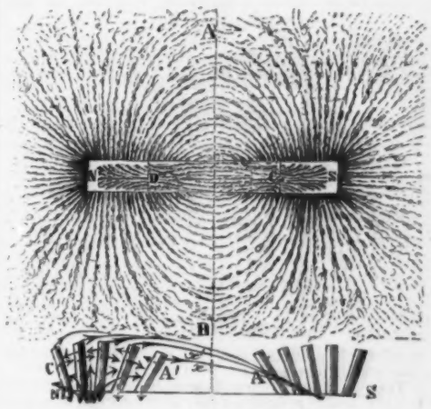
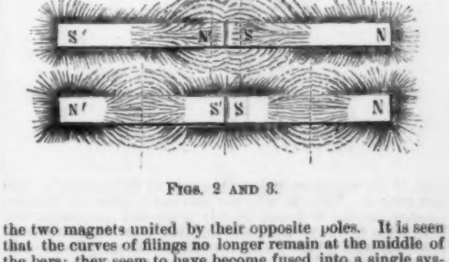



FIG. 1.

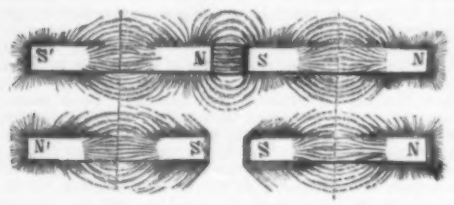
magnet, N S, the neutral line of which is at A B. The figure is so styled which is formed by iron filings strewn over a sheet of paper placed beneath a magnet. The filings collect together according to certain so-called lines of magnetic force, which radiate around the poles and unite toward the neutral line to form more or less pronounced curves that indicate the neutral region of the magnet. The small figure seen beneath the larger one shows how, in consequence of magnetic attractions and repulsions, these aggregations of particles of iron produce these lines of magnetic force. I have spoken of this at some length in my work "On Magnetism," and without attaching as much importance to it as the English do, I will make use of it here merely as a means of easily recognizing magnetic distribution in magnetic systems of greater or less complexity. Consequently, when we see curves of iron filings in a magnetic phantom, we may be assured that the normal line in the middle of such curves will represent the neutral line of the system. This granted, let us now examine the phantoms of two equal magnets united by their like and unlike poles. These phantoms are represented in Figs. 2 and 3. The one in Fig. 2 belongs to




FIGS. 2 AND 3.

the two magnets united by their opposite poles. It is seen that the curves of filings no longer remain at the middle of the bars; they seem to have become fused into a single system, which ought to furnish but a single neutral line were the adhesion of the two magnets perfect, but which, by reason of their imperfect contact, gives rise to two distinct neutral lines. The phantom of Fig. 3, on the contrary, shows that the distribution of magnetism has been little altered on each of the two magnets, since the two systems of curves are found to nearly correspond in the middle of each. When these magnets are separated by a slight space, the phantoms exhibit themselves in the form seen in Figs. 4 and 5, and which show that the magnetic field, in cases where opposite poles are in presence, behaves like a true magnet—conditions which do not exist when like poles are opposed

to each other. When, instead of two magnets, we employ a piece of iron and a magnet, or, in other words, when we employ a magnet provided with an armature (as in Fig. 6), the phantom of this arrangement shows that the neutral line of the magnet has not returned to the point of contact of the two pieces. It has slightly approached it, it is true, but the threads of filings which radiate around the pole, S, and the whole surface of the armature, P, show that, as regards static action, this armature forms only an expansion of the magnetic pole with which it is in contact. Consequently, it is polarized over its whole surface, and, nevertheless, as we have demonstrated in another article, the effects induced in this case (see Fig. 3) show that this neutral line, where the




FIGS. 4 AND 5.

resultant of the spirals of the magnetic helix should be applied, correspond indeed, as regards dynamic action, with the point of juncture of the two magnetic pieces. If the iron armature is far from the magnet, as shown in Figs. 7 and 8, the threads of filings of the magnetic pole bend over on the part of the armature nearest this pole, and consequently show that a north polarity has become developed at P; but the rest of the armature seems to be polarized in the same manner as S, for the threads of filings are normal at its surface and indicate no such system of neutral line as has place on the magnet. If now we examine the effects which result from the reactions exchanged between a magnet and its armature, as regards the magnetic power of the system, and which we may do by means of the apparatus represented at Fig. 9, we find:

1. That the attractive force of the pole provided with an iron armature has become considerably weakened, but that,

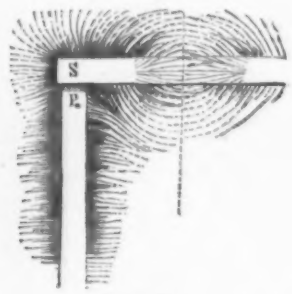



FIG. 6.

as an offset, the attractive force of the opposite pole has become greatly increased.

2. That the induced currents resulting from the addition of this iron armature have not only increased in a large proportion, but may be super-excited by the simple approach or withdrawal of the armature.

3. That the action is still greater if the magnet is provided, at its two poles, with two armatures.

4. That if the magnet is an electro-magnet, the armatures remain firmly attached to the poles, even after the current has been interrupted through the electro-magnet, and that too with the softest irons.

From these effects it follows that magnetism, considered from the standpoint of static action, behaves like electricity in a condenser. The polarities which are in presence are kept developed one by the other in a *hidden state*, for their presence cannot be ascertained externally; and on the surfaces of the magnetic pieces in contact there remains only the magnetism which has escaped condensation, and which is of the same character throughout the whole circumfer-

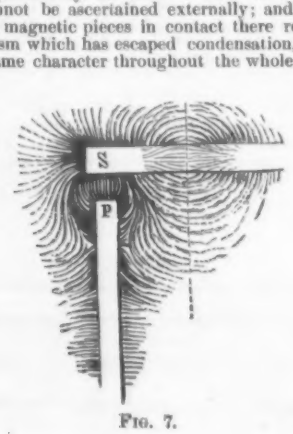



FIG. 7.

ence of the armature and on the pole of the magnet in contact with it. This is why the attractive force of this expanded polarity is found greatly weakened in comparison with what it was at first; and in fact this weakening corresponds with all the magnetism hidden at the point of contact of the two pieces. But this magnetism is none the less active on account of being hidden; it might even be said that it has become more active than it was originally, since the induced currents that are then produced are more energetic. I ought to say, however, that the expression "magnetic condensation," which I employed at the beginning of my researches, in 1858, and which other physicists have used since, is perhaps not quite proper, for it supposes an *increase* of magnetic energy in the phenomenon, and which ought to be kept up independently of the cause of the magnetism, but which, in fact, disappears with it, giving rise after this disappearance to a secondary magnetic action, which varies according to the energy of the magnetization developed, and which has this time all the characters of a condensing action. For the polarities excited on the surface of contact of two magnetic pieces having an action on each other are kept developed in consequence of their mutual reaction, even when the magnetizing cause has disappeared; and in order to annul this action it is necessary to either mechanically separate the two pieces in contact or to destroy one of the two polarities by a contrary external magnetic action, as shown at SNS' in Fig. 9. Now it is on account of this secondary magnetic action, which is evidently connected with the first, and of the increase of strength of the magnetic action itself, that I have given the phenomenon the name of *magnetic condensation*.

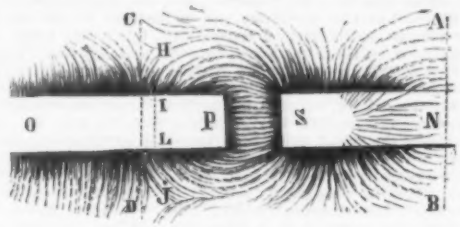



FIG. 8.

In the different notes that I have presented to the Academy of Sciences, at various periods, and especially in 1873, I have shown that these effects might be explained by the accepted theories without having recourse to a hypothesis of a displacement of magnetic fluids; I will not refer to these then, but will only say that the induced currents resulting from this magnetic condensation which M. Lallemand has said that he has obtained without any change of intensity at the end of twenty days, may be produced at the end of an infinitely longer period. I have found them not only at the end of several months, but even of several years.

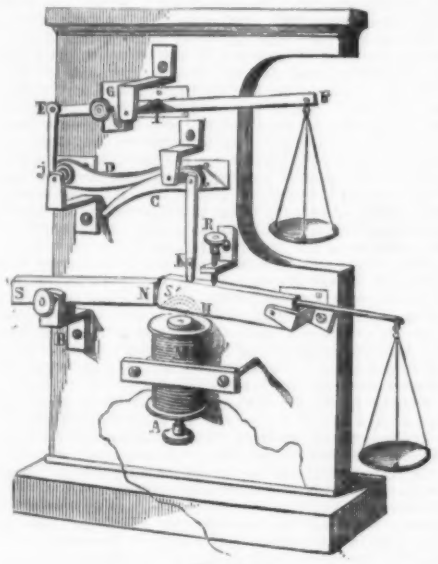



FIG. 9.

Could a charge of electricity, like a magnetic polarity, be maintained without loss on a conductor, it is probable that the charge of a condenser could be preserved indefinitely in the same manner.

*Condensed magnetism* is generally confounded with *remanent magnetism*; but these, however, are two very distinct actions. The first of these is a physical effect of a positive kind, but the other is only the result of impurity of the iron. The latter can be recognized only when the former has been annulled, and it only makes itself manifest when, after a first removal of the armature, the adhesion of the two pieces of iron tends to take place. One of the most manifest

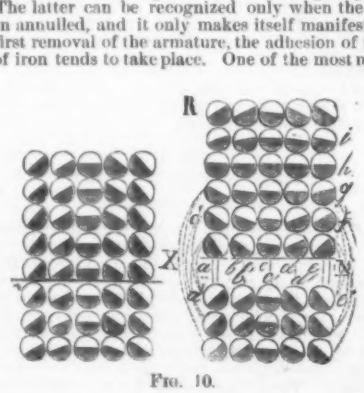



FIG. 10.

proofs of magnetic condensation is that experiment which I described in 1859, in my memoir on Induced Currents (p. 26), and which shows that when magnetization is super-excited the first time in a magnetic system composed of an electro-magnet united with its armature, the *induced currents produced by closing, and which result from this magnetization, are infinitely more energetic than when they are excited a second or a third time.* Now what proves that this weakening is due to a condensing action is, that to these currents may be given again their first energy, by separating for a moment the electro-magnet from its armature, and in remagnetizing the system after having re-established the contact of the two pieces. The influence which is exercised under such conditions may be easily ascertained by studying the difference of tension of the induced currents produced by an electro-magnetic system (with an induction coil) provided or not with its armature. When the armature is in contact with the electro-magnet, the deflection of the galvanometer which is produced by the induced current resulting from demagnetization is much greater than when this contact does not exist, and nevertheless the *perturbations that are caused by these currents are incomparably stronger in the latter case than in the former*, and that is because the demagnetizations are effected in a much less abrupt manner with the armature, in consequence of the impediments offered by the effects of condensation.

In the memoirs which I have published on these effects of condensation, I have, again, given as proofs of their existence, the enormous increase of power which a permanent magnet acquires when it is magnetized by providing its poles with an iron armature. Thus M. Jamin has been able to give a magnet placed under these conditions an attractive power of 780 kilogrammes, although he could communicate to it

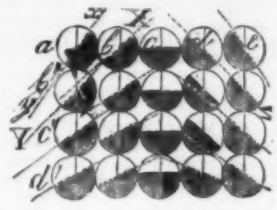



FIG. 11.

only one of 300 kilogrammes without the presence of the armature. On another hand, I explained by this action the attraction that takes place between two magnetic poles of the same kind, but of different power, when their distance is slight enough to allow the static effect to overcome the dynamic. In order to explain all of these effects, I said that the *atomic polarities* of the magnetic molecules which constitute the chains of currents of a magnet's magnetic helix assume an *arrangement which varies according to the conditions of the magnet with respect to the bodies that surround it, and to their relative positions.* If the magnet is influenced by no body situated in its vicinity, these atomic polarities arrange themselves so as to constitute among themselves such a state of equilibrium that the polarities of contrary names are as opposite to each other as possible (as seen in Fig. 10), and the result of it is different polarities with two centers of action designated by the name of poles.

If, now, we admit that a magnetic body is submitted to the action of these polarities thus distributed, the latter excite a reaction by induction, which has the effect of causing the axes of the atomic polarities to assume a new position of equilibrium and a new arrangement, which displace the centers of action or poles, and carry them toward the body induced, by producing in the attraction and in the polarities themselves an action which is so much the more lively in proportion as the bodies are nearer each other. Now this action is at maximum at their contact (see Fig. 11), but for all that the current does not the less remain in force; just as an electric current traversing a submarine cable does not any the less act as a dynamic source, although at the same time it produces laterally a static action. Finally, when we present a second armature to a magnet provided already at one of its poles with an armature, the atomic polarities are induced anew, and to satisfy the double action which is caused, they take a new position of equilibrium which can be produced naturally only to the prejudice of the first action, and that too in a degree nearly proportional to the mass of the bodies induced, and especially to their surface.

To thoroughly comprehend these different considerations, it would be necessary to enter into the theory of magnetism and diamagnetism given by M. De laRive. Some day perhaps we will attempt to resume it; but what concerns us at the present time to fully demonstrate is, that the effects of magnetism, like the effects of electricity, are of two different natures, according as magnets act as currents or as charges in the static state.—*La Lumière Electrique.*

## NEW PROCESS FOR PHOTOGRAPHIC PRINTS.

By M. A. POITEVIN.*

IT is well known that peroxides and salts corresponding to the higher oxides, when mixed with certain organic bodies, such as alloxanthin, tartaric and citric acids, and probably other analogous substances, are reduced by the action of light to protoxides and to salts corresponding to the lower oxides. For instance, ferric chloride ($Fe_2Cl_6$) mixed with tartaric acid and acted on by light, is changed to ferrous chloride ($Fe_2Cl_4$), a reaction that has been taken advantage of in the production of permanent prints by the powder process and in that of vitrified enamels. M. Pellet makes use of the same reaction for copying plans, etc., in blue lines on a white ground. A similar experiment may be made with corrosive sublimate (mercuric chloride, $HgCl_2$), which is reduced to the condition of calomel (mercurous chloride, $Hg_2Cl_2$), and then blackens on being treated with ammonia. These different photo-chemical reactions may all form the foundation of photographic printing methods.

The process which I have the honor of introducing to the notice of the society rests upon a similar reaction. Its object is to facilitate photographic printing by rendering unnecessary the use of a superior quality of paper and other costly materials, and, above all, by dispensing with the delicate operation of fixing by means of sodium hyposulphite; for the latter is substituted a few washings in rain water.

In my experiments I use common scribbling paper, though I have no doubt that a finer quality would give better prints than those which I send to accompany this communication. I coat the paper with sesquioxide of iron rendered sensitive to light by a concentrated solution of tartaric—or, better, of citric—acid. This paper after being dried in the dark, and then exposed to the light beneath a negative, has the property of reducing a solution of silver nitrate, or of gold chloride, and of turning blue a solution of potassium ferrocyanide, in every part where the light has reduced the sesquioxide of iron to the lower oxide.

In order to obtain an even layer of the sesquioxide all over the paper, I brush the surface well over with a linen cloth dipped in a ten or twelve per cent. solution of ferric chloride, and then hang up the sheets to dry in a dark room. Next, I plunge these sheets one by one into a dish containing the liquid ammonia of commerce, so that each sheet is thoroughly wetted in succession. When a sufficient number of sheets have been immersed, I pour back into a special flask the ammonia solution, and then wash them several times in the same dish. I take them out separately, and hang them up to dry; this may be carried out even in full daylight, as the iron sesquioxide alone is not sensitive. The

* Read before the Photographic Society of France.

paper in this condition may be prepared beforehand; when I want to use it, I apply with a cloth, by the light of the operating room, a thirty to thirty-five per cent. solution of citric acid, and let it dry in the dark.

With a negative of ordinary intensity, the print is taken in the sun in a few minutes, and in the shade in about the same time as is required for silver chloride paper. After exposure, the image is not visible; to develop, the sheet is immersed in a one per cent. solution of silver nitrate, whereby it is not necessary to take extraordinary precautions against the penetration of light.

I have not found it requisite to take any particular standard for the salt. The bath can be used again as often as may be required by adding a little more silver nitrate; it does not grow turbid, but takes a light green color, owing to the ferric nitrate that is formed in it. The image will soon make its appearance, and rapidly acquires intensity, so that in half-an-hour it will be fully developed. If the exposure has been long enough, the print will be of a dark sepia color, but the tint will be of lighter, if the citric acid solution was too weak. The print can be intensified with great ease by means of a very dilute solution of either gold or platinum chloride, or, better, by both salts together.

By dipping the paper on which the impression has been taken into a weak bath of potassium ferrocyanide, a beautiful print in blue is obtained. A very dilute solution of chloride of gold will also develop the image of a violet color, but one of platinum chloride produces no result. All the operations of this process can be carried on in the open daylight, except that of drying the paper that has been sensitized by citric acid; this must be done in the dark. The paper when prepared can be kept for any length of time until it is wanted, and there is no fixing by sodium hyposulphite required. So far as the photo-chemical reaction is concerned, I think the invention is complete; there remains now only the artistic question to be solved. That a solution will be soon discovered by our skillful photographers, I hope and believe. I invite them heartily to take it up and to study the process.

## A GELATINE FILTER.

THE diagram is an illustration of an apparatus I have had made for filtering gelatine emulsion. It is very simple but most effective, and made entirely of tin. A D is a tin cylinder with partition, E F, adjusted about midway in the cylinder. G a funnel (of tin) soldered to partition, at H, where the tin funnel terminates. I is the lid made flat, and fits in at A B. When the apparatus is in use warm water is

placed in the upper portion of the cylinder, and a glass funnel placed in the tin funnel, G. The tube of the glass funnel enters the bottle, K. The cylinder is made without a bottom to it.

The apparatus, when not in use for filtering, answers admirably for a plate warmer. The lid is placed on, and a lamp takes the place of the bottle, K.—*Geo. J. Tear, in Brit. Jour. of Photography.*

## PHOTO-ENGRAVING PROCESS FOR SURFACE PRINTING.

By HENRY KNIGHT.

| | |
|---|---|
| Gelatine | 1 drachm (60 grs.) |
| Bichromate of ammonia sol. | 3 drachms. |
| Water | 9 " |
| Ammonia bichromate | 1 drachm. |
| Distilled water | 2 ounces. |

Bichromate of potash will answer equally as well as bichromate of ammonia.

Add the water and the bichromate solution to the gelatine, and when thoroughly swollen, melt over boiling water and strain through fine muslin. Two drachms of the gelatine solution is sufficient for a 6½ by 4¾ plate. Take a piece of patent plate glass (say a half-plate), warm it over gas or before the fire, and carefully level it with a spirit level. Then take two drachms of the warm gelatine solution; pour upon the glass a little at each corner and in the middle, guide it over the glass with a glass stirring-rod, and dry at a temperature not exceeding 75°.

It must now be printed under a negative in direct light at the bottom of a box so as to exclude all vertical rays. The printing takes about half an hour in summer, and from two to three hours in winter in the sun. The printing must be carried out thoroughly, as success or failure entirely depends upon this part of the operation. The image must be well defined upon the back of the glass; fine lines and stipple work must be as distinct and clear as the broader parts.

When printed it can be put into water at a temperature not higher than 80° or lower than 60° to swell. When all the undecomposed bichromate is washed out (which takes about fifteen minutes) it must be put into a solution of—

| | |
|---|---|
| Proto-sulphate of iron | 40 grains. |
| Water | 1 ounce. |

The temperature of this solution must be from 60° to 80°, and I find the common sulphate answers better than the pure sulphate. It must be occasionally moved about, and after being in about ten minutes, it can be taken out and washed with water under a tap for two or three minutes, and the superfluous water taken off with blotting paper. The iron solution hardens the gelatine film and prevents it sticking to the plaster.

A plaster mould can now be made as follows: Take some fine plaster of Paris, and mix with water to the consistency of cream; put a frame upon the plate, then pour some of the plaster upon it, and stir it about with a camel hair or badger hair brush until it is very thick (the stirring prevents air-bubbles), then pour on the remainder of the plaster, and scrape off level with the top of the frame.

After the plaster is set, which takes about fifteen minutes, it can be separated from the glass plate. This gives the picture in relief the same as a wood block. Another mould in plaster must now be made from this.

The following plan I have found the best: Take half a pound of soft soap, put it into three pints of clean water in any convenient vessel, which is set on a clear fire, and the solution kept in agitation by stirring. When the mixture begins to boil, add half an ounce of tallow and keep boiling until it is reduced in bulk to two pints, when it is ready for use. To prevent the two plasters from adhering, the surface of the plaster mould must be washed over with the above lacquer, allowing it to absorb as much as it can, when it assumes the appearance of polished marble. It is now prepared for moulding by laying a frame upon it, and a plaster mould made the same way as directed for making a plaster mould from the gelatine relief. When hard, which takes about fifteen minutes, they will readily separate.

A cast can now be taken in stereo metal, which can be done at any stereotype foundry, and after cutting out the broader portions, it can be mounted upon a wood block, when it is ready for use to print in any ordinary printing press. If the above operations are carried out successfully, the stereotype cast should be as deep and the edges as sharp as any woodcut.

## HOW TO MAKE LAGER BEER.

FOR one brewing (80 barrels in copper, to be pumped on cooler), equal to 60 barrels net lager (one-quarter is a liberal allowance for loss from evaporation, yeast and yeast sediments, in storage and on shavings), have averaged from 70 to 75 barrels of water altogether on hand to begin mashing.

We calculate two and a quarter bushels of malt at 34 pounds for each of above 60 barrels net beer, equal to 135 bushels.

Before mashing have a quarter barrel of water for every bushel of malt used (or if machinery is strong enough, less water) of a temperature of 149° F. in mash-tub, say 33¾ barrels, then let the malt run in, and mash vigorously for about 15 to 20 minutes; after the malt is all in, the mash, if possible, should not show less than 122° F by thermometer outside of mash-tub; then let balance of water, which must be boiling, and which is about 40 to 45 barrels, run into mash-tub, having kept the rakes going all the time, run the mashing machine gradually slower, stop water from kettle when mash shows 163° F. (or sometimes 167° F.), keep on mashing for 30 to 40 minutes longer, say about one hour altogether, and then stop, when mash should show, as near as possible, 158° F., and no more than 163° F. If necessary, let some worts run out from under the false bottom, and throw them back into the mash tub to clear the pipes and cocks; leave the whole to stand for one hour to develop saccharine; then open cocks at underback and pump the worts, as long as they do not run off clear, back into mash-tub, over the goods; when it runs clear pump into kettle immediately; it will give altogether about 50 or 55 barrels in copper; throw some hops in, to keep beer from rising and flowing over, if you boil by direct heat.

When these worts are run off, or a little before, sparge about 40 barrels at a temperature of not higher than 178° F., nor lower than 167° F. Those 40 barrels you can let run over grains, say 25 barrels at first and 15 barrels afterward. This ought to give you about 88 to 90 barrels altogether in a fire copper, and would boil down with a vigorous fire to about 80 barrels in about two hours. A steam copper does not boil down so rapidly, and you must therefore make allowance.

We give for present use lager for above 60 barrels about 65 pounds No. 1 new hops, or 80 pounds old, according to quality; have found no difference in mode of giving them, but found it the most advantageous to put the last three-quarters or two-thirds in, when the beer is boiled perfectly clear, and then the whole ought not to boil more than one hour longer. Lager to be kept from four to eight months gets from 50 to 100 and 150 per cent. more hops, and is boiled longer in copper, which in the present brewing would amount to from 90 to 120 or 150 pounds hops and more, because the gravity ought to be higher than the above, which will show from 13 to 14 per cent. extract by Kaiser. Lager brewed for summer months needs less gravity and less hops, if the temperature in the cellars is kept low.

Cool beer, down to 43° F., I give yeast, if of good quality, from three-quarters to one pound per barrel, viz., 45 to 60 pounds; 60 pounds will be found the nearest right. When beer runs into fermenting tub at 43° F., it ought to show 13 to 14 per cent. extract by Kaiser; this is pretty strong. Bock Beer is plenty strong enough at 17 to 17½ per cent. In pitching, strain all the yeast through a fine hair sieve; when sifted, add, if you want—though it is now obsolete—malt meal or some brandy or flavoring. The safest method, and that insuring the most regular, even fermentation—particularly if you do not know the quality of your yeast—is to let from one to two barrels of beer run from cooler at temperature 52° or 54° F., throw yeast in, and in one or two hours it will be in kraüsen, when you run or pump the whole into the large fermenting tub.

In about 24 to 36 hours, the top will be getting white, and in 12 hours more it will be in kraüsen (white curling). At this stage you must take what kraüsen you need for your shaving casks. Judgment will tell whether they ought to be taken quite fresh or a few hours older. I found them better a little older; the beer will get a more solid foam.

Let the beer not get higher than 52° F. during fermentation, though many brewers do not let it go beyond 46° or 48° F.; 50° I judge to be the best. At this temperature, say 50°, the fermentation will last from 12 to 14 days. (Dreher, the largest lager beer brewer in the world, has no larger fermenting vats than 25 or 30 barrels; they give the healthiest fermentation).

If you use moss, you must skim the beer, for the purpose of getting white and good stock yeast. It is better to have separate vats for giving the yeast, and when the beer is in kraüsen, and after kraüsen have been taken out by a hose from on top, pump the remainder into your fermenting tubs.

The beer is ripe to be put into storage casks when it is what is called "fallen" and looks pretty black. Although it looks clear on top, in vats 5 or 6 feet high, it is still pretty thick lower down. Always skim off all dirt before running the contents of a vat into casks.

Keep in casks according to sales from 3 to 30 or 60 days—bung not in tight.

When put into shaving casks (I judge about one barrel full of dry shavings not packed very close, is enough for a 16 barrel cask) about one-seventh part is enough of kraüsen if beer is not too old, one-eighth if new, and one-sixth part if old.

Drive bung in tight to make kraüsen work quicker. Keep in for a few hours and then take it out, when it will work out of bunghole. Keep filling casks up with clear beer (some take clear water) for three or four days, when it ought to be clear; anyway do not let it work out of bunghole any longer, or it will get too flat. If not clear enough put in finings, and quick as it is brilliant bung it up. Two or three days bunging is generally sufficient. The object of all this is to have your beer abgelagert, viz., old enough, and afterward not more than seven to ten days (according to circumstances) on shavings. If it has the right amount of kraüsen, is bunged at the right time, at a low temperature, and has been brewed from sufficient malt, it will carry a solid head and lasting foam.

In bunging casks, some fill up with spring water, some with brilliantly clear beer. The latest fashion is not to fill up at all (or also to pump some air in); the beer will foam nicely in due time anyhow. I judge filling up with clear beer to be the best.

In drawing off into halves and quarters, one tablespoon heaped full of bicarb. soda is generally put in a quarter barrel, other barrels in proportion. If the beer be new, about one-third of an inch cube of tartaric acid will help soda to be more effective. Old lager has sufficient natural acidity.

In reaching beer from fermenting tuns into storage casks or vats, bring the temperature down, if at all possible, by means of swimmers, if it does not come naturally to 43° F.—43° or less is the right temperature for the proper amount of carbonic acid gas to be developed and kept in the beer.

Shaving casks can be filled twice and even three times in winter after being racked into kegs, but if the beer has been too green (or new) and particularly in summer it is better to take the shavings out to clean thoroughly with hot and last with cold water, and also the cask, which must be cleansed by a workman going in through the manhole. Always bung up casks after racking off, and draw remnants off and put into a remnant cask, where you can also put wastage in racking off into kegs.

In giving stock yeast of known good quality, mix strained yeast with about same amount of unfermented beer, from the brewing which is to get the yeast and at about 43° F. Shift it from one handbucket into another to mix it, it will raise up in a few minutes, and be ready to be thrown into the fermenting tun. Always stir up the vat thoroughly.

To give aroma to beer, take one pound of roasted laurel berries, ¼ pound cubebs, ¼ pound rad. florent, ¼ white cinnamon, ⅛ mace. Must be pulverized and all well mixed.

### REGULAR BAVARIAN THICK MASH.

You need nearly double the amount of water, of net beer produced. First mash no higher than 95° F., pump or dip as much thick mash, viz., malt and worts, into copper, as is necessary to cover flues or coil; keep stirring well, so it does not burn, until it boils, then it will rise; keep it at boiling point from 15 to 20 minutes, let it run over into the mash-tub enough to raise the temperature of the mash to 118° F.; now mash again as before for the second thick mash, and get a proper quantity of thick mash into copper, stir up, boil and return to mash-tun, as before. The next mash (or lautermaisch) is made at 140° F.; get, if possible, all thick stuff from copper into the mash-tub. As soon as you are done mashing, let the worts run out of cocks into under-back and pump into copper, where boil until it is clear and albumen well separated; have enough worts in the copper to make last mash at from 163° to 167° F. After mashing, let some worts run into under-back to clean out from under bottom. Leave the whole stand one hour for formation of saccharine, and afterwards proceed as before and sparge as much as necessary.

Some, to get through quicker, make one thick mash, and, of course, one lautermaisch.

### LAUTERMAISCH.

A great many brewers, in cold weather, mash first with cold water in the evening and let it stand, or commence some hours before regular mash in the morning.

First mash is made sometimes at 95° F. (by some at 106° F); worts run out of cocks and boiled proper length of time.

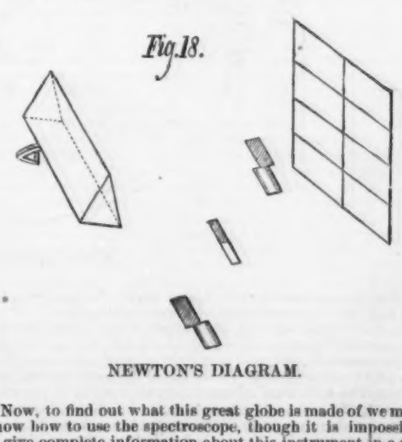
Second mash at 127° F. (some at 140° F.); always as soon as mashing is done let worts run and boil in copper.

Last mash is made at 163° to 167° F.; everything else as before.—*American Brewers' Gazette.*

## THE SPECTROSCOPE IN SOLAR WORK.

WE have hitherto been looking at the sun as spectators, and may have begun to get some idea of the changes visible there to the telescope on a vast diversified surface, which, to the naked eye, is an unaltering white disk.

*Fig. 18.*



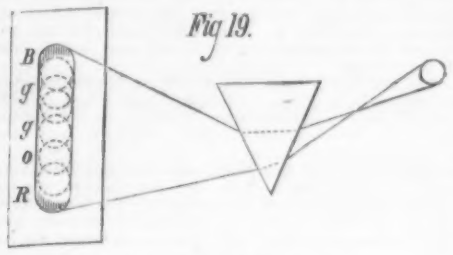
NEWTON'S DIAGRAM.

Now, to find out what this great globe is made of we must know how to use the spectroscope, though it is impossible to give complete information about this instrument in a single article. No such attempt will be made here, and this chapter is addressed only to those who are ready to admit to themselves a great deal of ignorance even about its fundamental principles. It would be assuming a good

deal to say positively that even these can be clearly explained to all in such space, but the trial may be made, and after this some of the more complex forms of the instrument presented.

To the reader, then, whose mind is in that healthy state where existing ignorance is frankly self-acknowledged, we will recommend to read with us a little from Sir Isaac Newton's "Opticks," the work in which the foundations of our present knowledge are laid, and which takes the student over the very path of discovery. Many illustrations from this survive unaltered in our modern text books, and in some respects, even as a text book, it might replace many

Fig. 19.




NEWTON'S DIAGRAM.

of its successors with advantage. As the first steps by which a Newton enters a new field of knowledge must always remain interesting, we give the first experiment of the "Opticks" as nearly as may be in his own words, and reproduce the rude illustration of the early text (edition of 1718):

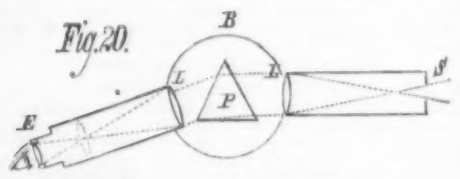
"PROP. I.

"*Lights which differ in Color, differ also in degrees of Refrangibility.*

"THE PROOF BY EXPERIMENTS.

"Exper. 1. I took a black oblong stiff Paper, terminated by Parallel sides, and with a Perpendicular right Line drawn cross from one Side to the other, distinguished it into two equal Parts. One of these parts I painted with a red color, and the other with a blue. This paper I view'd through a Prism of solid Glass whose two Sides through

Fig. 20.




ESSENTIAL PARTS OF SPECTROSCOPE.

which the Light passed to the Eye contained an Angle of about sixty degrees: which angle I call the refracting Angle of the Prism. And whilst I viewed it, I held it and the Prism before a window in such manner that the sides of the paper were parallel to the Prism, and both those Sides and the Prism were parallel to the Horizon, and the cross line was also parallel to it. Beyond the Prism was the Wall of the Chamber under the Window.

"These things being thus ordered, I found that if the refracting Angle of the Prism be turned upwards, so that the Paper may seem to be lifted upwards by the Refraction, its blue half will be lifted higher by the refraction than its red half. But if the refracting angle of the Prism be turned downward, its blue half will be carried something lower thereby than its red half. Wherefore in both cases the Light which comes from the blue half of the Paper through the Prism to the Eye, does in like circumstances suffer a greater Refraction than the Light which comes from the red half, and by consequence is more refrangible."

Up to Newton's time it was supposed that white light was the purest thing in nature; that, if colored, it was because it was contaminated, and that light of any color was bent out of its course (that is, refracted) in the same degree by a prism. The extremely simple experiment we have just cited is, then, of fundamental importance. Simple as it is, perhaps none has ever been made in optical science of more consequence, for in Newton's hands his "Proposition I." which we have just given, led immediately to his "Proposition II.," which we will also cite in part; a proposition from the enunciation of which the whole of our present knowledge of the subject may be said to date, and with which begins the progress to which we owe the Spectroscope of to-day.

"PROP. II.

"*The Light of the Sun consists of Rays differently Refrangible.*

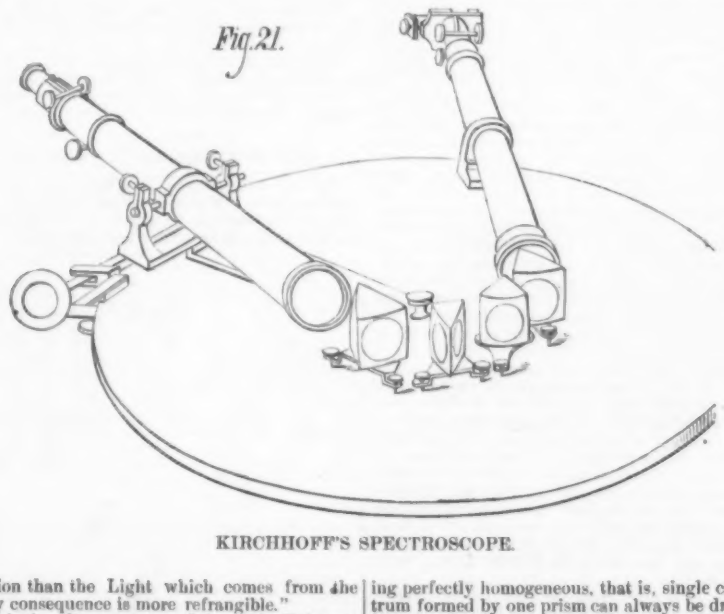
"THE PROOF BY EXPERIMENTS.

"In a very dark chamber, at a round hole about one-third part of an inch broad, made in the Shut of a Window, I placed a Glass Prism, whereby the beam of the Sun's Light which came in at that hole might be refracted upwards toward the opposite Wall of the Chamber, and there form a color Image of the Sun."

This colored image, Fig. 19, he goes on to show, would have been a circle had the sunlight been of uniform refrangibility. But in fact the refracted image is not a circle, but an oblong figure, five times as long as broad, colored red below and blue or violet above, and with semicircular ends. To give his interpretation in our own words, he finds that the white sunlight really contains all colors. If it were blue light only a perfectly round blue image of the sun would be formed at B. The prism would, in this case, simply throw the image of the blue sun on another part of the wall from where it would otherwise fall (as in the first experiment), but it would in no way distort that image. If the sun were red, a perfectly round red image of it would be formed at R, lower down. But the white light really contains all colors between these two, and therefore not only blue and red, but also green, yellow, and orange circles will be formed, as at *g*, *g*, and *o*; and not only this, but every shade between blue and green, between green and yellow, etc., will be represented by a separate circle. The overlapping of innumerable circles then obliterates the circular form, except at the extreme opposite ends, where the furthest visible colors (violet and dark red), having nothing visible beyond to overly them, show the semicircles which terminate the figure. The breadth of the image is greater than that of the hole in the shutter, because the light diverges as it passes through the opening. If we want the width of the colored band (spectrum) to be the same as that of the hole, we need only place a lens behind the prism at a proper distance to make such a picture of the hole on the screen if the prism were not there, and whatever the shape of the aperture, the ends of the spectrum will now reproduce it. Usually the aperture is made, not a circular hole, but a long slit, and hence the ordinary spectrum, drawn as a rectangle, being made of numberless overlapping images of the rectangular slit, and being of course, in this case, terminated with square, not circular ends. Now let us see how we can improve on Newton's primitive apparatus, for, standing on that great man's shoulders, we can doubtless reach higher than he.

We do not need to darken a whole room, or to spoil our "window shut" by boring holes in it, and if we take away the screen and put the eye there, we shall get all the more light. We shall do better yet if we put a telescope between the eye and the prism, to make sharp enlarged pictures of the slit on the retina; and if one prism is good, two or even four will doubtless be better. [A perfectly single colored image of the slit would not be drawn out by two prisms (or by twenty) any longer than by one, but in practice the blue or green formed by passing through a single prism not being perfectly homogeneous, that is, single colored, the spectrum formed by one prism can always be drawn out further by going through another.] Let us, as a last improvement, put a lens (called a collimator) between the slit and the prism, to make the rays parallel before they reach the latter, and we have the modern spectroscope, with which the reader is familiar, at least by engravings, as in Fig. 20. S is the slit which has replaced the hole in the shutter of Newton's day, P is the prism in the little circular box, B, which replaces the darkened room, E is the position of the eye lens, L L', of the telescope and collimating lenses.

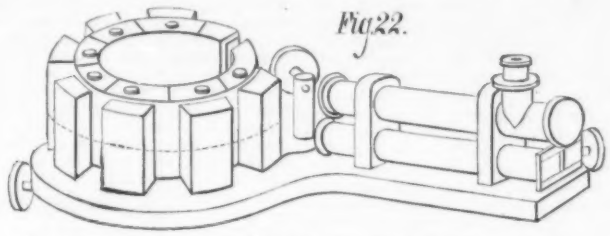
Fig. 21.



KIRCHHOFF'S SPECTROSCOPE.

Now turn to a little larger instrument, where the same principles are embodied, as in Fig. 21. It is that with which Kirchhoff and Bunsen made their great map of the spectrum, published in 1861, together with the discoveries to which we shall shortly recur. It will be noticed that the light comes through a slit (at S) from a direction which must be nearly behind the back of the observer, who sits looking in at E. In fact the four prisms bend the light round till the rays almost make a letter U. There is a screw by which the width of the slit can be altered, and the position of the observing telescope and of the prisms can be adjusted so that the ray enters and leaves each of these at the same angle, an important point, which Newton called attention to. But the instrument just shown has been far surpassed by others made since, in which the light has been bent more and more, and the spectrum pulled out longer and longer. After bending it into a U, it was bent so that the rays traveled through more than a semicircle, and the prisms were ranged on a horseshoe shaped curve. Beyond this it might seem that they could not go, without returning on themselves, but there have been many ingenious ways for carrying the dispersion further. Thus, in the annexed illustration, Fig. 22, we may suppose there are two rows of prisms, one over the other, like first and second story rooms along a curved gallery. The light enters through the slit in the lower tube, which contains the collimator, passes round the circle nearly to the point where it came in, is there reflected up and then back, returning on the second story, whence it passes into the observing telescope. In such a way the light may be sent forward and back an unlimited number of times, but in practice the loss of light and other difficulties prevent our going very far in this direction, and in some of the most powerful instruments recently made the disposition has been shown to decrease the number of prisms, and increase their size together with that of the collimator and observing telescope.

Fig. 22.



YOUNG'S FORM OF SPECTROSCOPE.

There is also a form of so-called "direct vision" spectroscope, where the light is caused to go nearly in a straight line from the slit to the eye, but this convenient method is not well adapted to powerful instruments. The variety even of astronomical spectroscopes, however, is endless, and we cannot pretend to indicate more than a few leading forms. Let us now recur to the spectrum again to see how the instrument is used. It must constantly be remembered that the spectrum is a reproduction of numberless images of the slit, if the latter is transmitting light of all colors; or that if the light have only a part of the colors which might possibly exist in it, images of the slit will be lacking where they would have been formed had those colors been present. Thus if I (Fig. 23) is the slit, and we suppose a whitish light to be made out of twelve absolutely pure colors, none of which shaded into the other, as colors usually really do, each is sent to its own place by the prism, and as it there traces an outline of the slit through which the light enters, we shall have twelve distinct images, at 1, the dark spaces between them corresponding to the intervals between the colors. If there be no such intervals, but the light entering the slit be pure white or a compound of every possible tint, there will be no place on the screen without its image; the images will obliterate each other, and we shall have a "continuous spectrum," as at 2, such as it appeared to Newton and to every one else down to the early years of this century. In 1814, Fraunhofer, a German who had greatly improved the manufacture of optical instruments, using an instrument composed like that in Fig. 20 (but without a collimator), saw for the first time, owing to the greater purity and more accurate figure of his prisms and lenses, a spectrum like that shown at 3, Fig. 23, in which certain images of the slit appeared to be lacking. Their absence made it look as though dark lines had been drawn across the spectrum, and these used to be called "Fraunhofer lines" from

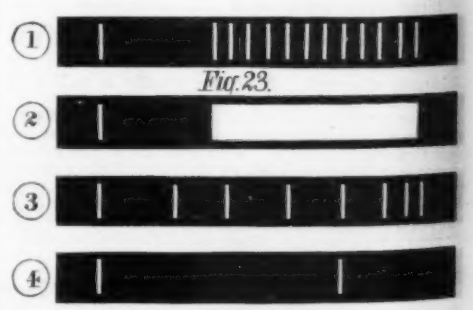



Fig. 23.

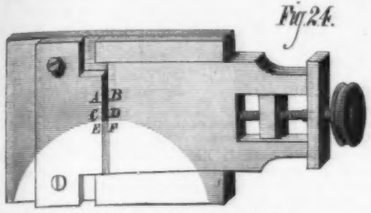
SLIT AND SPECTRA.

their discoverer. There were a good many, but he named the principal ones A, B, C, D, etc., after the first letters of the alphabet. Most of these lines could be found only in direct or reflected sunlight, though some of them, he discovered, were also in the light from certain stars. A lime light or a piece of white hot iron gave none. It was also discovered that if you salted the wick of an alcohol lamp, quite another kind of effect was produced by its flame. Only one image of the slit was formed, and the spectrum (a discontinuous spectrum), 4, Fig. 23 (which appeared to be in exactly the same part of the spectrum as the black line, D, in the sun), was reduced to a single yellow line. Brewster observed that new dark lines appeared when the sun was near the horizon, but very little else was added to our knowledge till the time of Kirchhoff and Bunsen's "Memoir," which was the most important in the history of the subject, and which appeared in the "Transactions of the Berlin Academy" for 1861.

With the apparatus drawn in Fig. 21, they not only made a map of the spectrum of wonderful completeness for the time, containing over a thousand lines, but they showed

what these lines, or rather gaps, in the spectrum were, and how they were formed in the sun. Taking the salted wick, or, better, the Bunsen burner, in which sodium was burned, to give the discontinuous spectrum of one yellow line, 4, Fig. 23, they showed that when any very brilliant light, like the lime light, was brought behind the flame so as to form a continuous spectrum, the yellow flame would let the blue or red components of the bright light pass through it, but would stop out the yellow of its own tint, being transparent to other gradations, but opaque to this. In the spectrum formed by both lights together, the yellow line really exists, nearly unchanged, brighter if anything than before, but surrounded by so much greater brightness that it seemed black by comparison. This is a particular case of Kirchhoff's general law that all heated bodies absorb the same rays which they emit. Kirchhoff showed that not only sodium, but a great many other metals, behaved in this way, and that a large part, at any rate, of the lines in his map were exactly coincident with those given by iron, barium, magnesium, etc. His proof that these metals exist in the sun is the immense improbability of such a number of exact coincidences being the result of accident. Thus, many hundred coincidences exist in the case of iron, which, burned in electrodes before the slit of the spectroscope, gives a discontinuous spectrum of many hundred bright

Fig. 24.

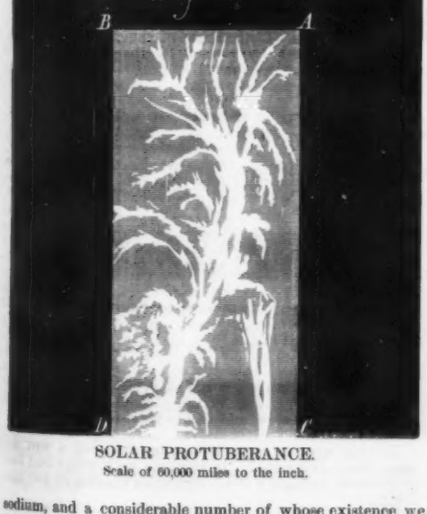



EDGE OF SUN ON SLIT

lines. Kirchhoff remarks that in a certain portion of the spectrum 60 of these lines were found to occupy the same positions with as many dark solar ones, and that hence, by a known rule, the probability that this is mere chance is at any rate less than $(\frac{1}{10})^{60}$; in other words, that the chances are more than one million of millions of millions against its being accident. As he made his dark lines at pleasure in the laboratory by passing an intenser light from behind, through hot metallic vapors, he concludes that nature proceeds in a like way to like effects, in her great laboratory of the sun. The sun, he supposes, in other words, to have a solid or liquid nucleus, very hot and bright, which emits white light, containing every shade of color, and which of itself would give a continuous spectrum; but that around this is an atmosphere of cooler though still glowing metallic vapors, each of which by itself would give a discontinuous spectrum. Each of these vapors, then, gives an actually bright image of the slit, which simply appears black in the spectrum by contrast with the greater brilliance of the background. We now know that it is not necessary to suppose either a liquid or solid background, but with this slight emendation Kirchhoff's theory is still trustworthy.

Since his "Memoir" was published we have discovered a good many more substances in the sun's photosphere. The list now embraces aluminum, calcium, cobalt, magnesium, iron, zinc, barium, chromium, hydrogen, manganese,

Fig. 25.




SOLAR PROTUBERANCE.

Scale of 60,000 miles to the inch.

sodium, and a considerable number of whose existence we are less sure, and there are others in the shell of cooler vapors surrounding the white photosphere. When, in a total eclipse, the passing moon just hides the body of the sun, and before it has hidden the shell, this shell should, according to our theory, form a spectrum of bright lines only, and this is what has been actually observed by Professor Young and others. During a second or two, after the moon has hidden the bright background, and before it has covered the reversing layer as it is called, nearly every line in the spectrum is reproduced, standing separately as a colored image of the slit, those which ordinarily appear black on a red background being now crimson, those in the green portion, green, and so on—beautiful but fleeting sight, which lasts only one or two seconds. In an extremely transparent atmosphere traces of this reversing layer (which is merely the densest portion of the thick stratum called the chromosphere) can be seen without an eclipse, and in fact at all times we can see many of the bright lines given from the chromosphere through the spectroscope when the telescope shows nothing. The chromosphere is always there, but, being composed chiefly of hot hydrogen and other gases or vapors which give far less light than the body of the sun, these are not hidden, but overpowered by it, as a candle flame would be beside an electric light. It is easy to see, though (once it has been done), how the spectroscope shows them. The hydrogen, for instance, shines chiefly by light of one color, a very beautiful crimson. If an image of the edge of the sun is caused to fall on the slit, so that the hydrogen light only enters, this, according to what has been said, passes through without being spread out or diluted by its passage through the prism, and comes through that to the eye as strong as where it falls on the slit. The white sunlight, however, if it enter beside the hydrogen rays, is pulled out into a long spectrum, and being spread, in a large instrument, over many thousand times the surface the other occupies, is proportionately diluted. The light which comes through an aperture, perhaps a hundredth of an inch wide, has thus been photographed by Mr. Rutherfurd in a picture ten feet long, every part of which is filled with dark lines. As there are 120 inches in 10 feet, if we suppose the slit to be $\frac{1}{100}$ inch wide, the white light has thus been weakened 12,000 times; and if it were originally a thousand times brighter than the colored ray from the chromosphere, the latter, preserving all its original intensity where it reaches the eye, would now be twelve times as bright as that which was at first so much stronger. Let A B C D E, Fig. 24, be a view of the slit placed so that its upper half, A B C D, is in the image of the chromosphere, its lower, C D E F, in that of the sun. In this figure we suppose ourselves to be standing in front of the instrument, looking at it. Evidently only light from outside the sun can pass through the upper part of the slit, but from our position we can see nothing but the bright round solar image formed by the telescope. The chromosphere is really there also, but overpowered by the bright sun, and invisible. Now let us suppose ourselves, Fig. 25, to look through the spectroscope, A B C D, being the same upper part of the same slit in the same position, but greatly magnified by the viewing telescope, which we here suppose to have an erecting eyepiece. The lower part of the slit, at E F, is lost to view, being pulled out into the spectrum along the line, C D, which now forms its upper boundary, and extends right and left far beyond the limits of the actual engraving. The upper part of the slit is thus seen like an open window, through which we are looking at the chromosphere, now plainly visible. One of its many beautiful forms (from a drawing taken from nature) is supposed to be in view.

We have no room to describe how certain lines in the spectrum are known to be formed by absorption in our own atmosphere, and distinguished from solar ones, and we are obliged to leave untouched the use of our instrument for measuring the velocity of solar storms.

Before the chapter is closed, however, we must mention the latest form of the spectroscope, in which the prism disappears altogether. Almost every one has noticed the colors on mother-of-pearl, and any one with a microscope may have noticed that these are formed by numerous fine lines, invisibly fine to the naked eye, traced there by the hand of nature. In mathematical optics it is fully explained why colors must be caused by the lines, and it occurred to Fraunhofer to produce these artificially, drawing lines on glass with a diamond by means of a ruling engine and micrometer screw. In this way he succeeded in producing a spectrum so pure that many of the solar lines could be seen in it as in that from a prism.

More recently Mr. Rutherfurd has constructed an engine of wonderful accuracy, and has ruled such groups of lines on speculum metal with a precision almost beyond belief. Fig. 25 is the full size of the ruled part of one of these, containing numerous lines, disposed as in the engraving, but so close that over one hundred lie side by side within the thickness of one of the lines of the woodcut. The beauty of the spectrum it will produce, however, depends much more on the accuracy of the spacing, even, than on the fineness, and it can be shown that, though some lines may be more and some less out of place, the mean error of position to produce the effect they actually do must be less than one six hundred-millionth of an inch, a quantity almost incredibly small, small even by comparison with the length of a wave of light, and far beyond the reach of the most powerful microscope. The microscope ceases to be of any use, in fact, in detecting the errors of the micrometer screw by which they are cut, and these errors can only be tested optically by the spectrum formed after the ruling is complete. It only remains to add, of this wonder of mechanical skill, that the little plate of metal, which can be hidden in the hand, is equal, optically, to the most powerful train of prisms yet constructed, and that these "gratings," for most researches on the sun, appear to be displacing all older forms of the spectroscope.

## HOW TO APPLY THE HOT WATER VAGINAL DOUCHE.

In the Chicago *Medical Gazette*, Dr. E. C. Dudley says:

The following is designed to impress the importance of strict observance of detail in the application of the douche, since in no other manner will its good effects be realized:

The ordinary method of application is as follows:

Ordinarily the douche is applied with the patient in the sitting posture, so that the injected water cannot fill the vagina and bathe the cervix uteri, but, on the contrary, returns along the tube of the syringe as fast as it flows in.

The patient is seldom impressed with the importance of regularity in its administration.

The temperature is ordinarily not specified or heeded.

Ordinarily the patient abandons its use after a short time.

The proper method of application is as follows:

It should invariably be given with the patient lying on the back, with the shoulders low, the knees drawn up, and the hips elevated on a bed pan, so that the outlet of the vagina may be above every part of it. Then the vagina will be kept continually overflowing while the douche is being given.

It should be given at least twice every day, morning and evening, and generally the length of each application should not be less than twenty minutes.

The temperature should be as high as the patient can endure without distress. It may be increased from day to day from 100° or 105° to 115° or 120° Fahr.

Its use, in the majority of cases, should be continued for months, at least, and sometimes for two or three years. Perseverance is of prime importance.

The sitting posture is especially objectionable, for another reason. It favors pelvic congestion by force of gravity, while the dorsal position utilizes this force during the application of the douche.

A satisfactory substitute for the bed pan may be made as follows: Place two chairs at the side of an ordinary bed, with space enough between them to admit the lower bucket; place a large pillow at the extreme side of the bed nearest the chairs, spread an ordinary rubber sheet over the pillow, so that one end of the sheet may fall into the bucket below, in the form of a trough. The douche may then be given with the patient's hips resting on the pillow and with one foot on each chair; the water will then find its way along the rubber trough into the bucket below.

## SUCCESSFUL CASE OF CHOLECYSTOTOMY.

At the Royal Medical and Chirurgical Society, Mr. Lawson Tait recently reported the first successful case of this operation. The patient had been married eighteen years, had borne six children, and menstruation was normal and health good till the summer of 1878. At that time she had spasmodic pains in the right side, aggravated by walking and lifting any light weight. A swelling noticed in September slowly increased, and during last winter pain became more intense, and she presented a cachectic appearance, suffering from incessant headache, sickness, and obstinate constipation. The seat of pain was over the right kidney, where there was a heart-shaped tumor, firm and elastic, without fluctuation, tender to the touch, and movable to each side. The urine gave only negative results. At a consultation with the author's colleague, Dr. Edginton, no decided diagnosis was attempted, and the opening of the abdomen was agreed upon, which was performed on August 23, in the middle line, to the extent of four inches. The tumor was found to be a distended gall bladder, containing a white, starchy-looking fluid, and two large gall stones, one lying loose and the other impacted in the entrance of the duct and adherent to the mucous surface. The latter was removed after a tedious and very difficult operation (fully described in the paper). The stone and fragments weighed 6·11 grammes. The wound in the gall bladder was stitched up to the upper end of the wound in the abdominal walls by continuous sutures, leaving the aperture into the bladder quite open, and closing the rest of the abdominal opening in the usual way. The operation was performed antiseptically, under ether. The patient rallied completely in a few hours, and the dressings of the wound were found stained with healthy bile. The flow of bile from the wound continued till September 3. The wound was completely healed on September 9, when the patient began to take solid food, up to that time the diet having been restricted to milk and beef tea. On the 30th she went home quite restored to health. A temperature chart indicated the evenness and rapidity of the recovery. An entire absence of symptoms of gall stone rendered an accurate diagnosis impossible, but this was of less importance, as late improvements in abdominal surgery made an early exploratory incision for ascertaining the true nature of the disease feasible. The author, in stating that he always used rigid antiseptic precautions in his abdominal sections, expressed some doubts as to his success being attributable in any way to them.

## SULPHITE OF SODA IN MALARIAL FEVERS.

Dr. L. Austin Porter says, in the *Michigan Medical News:*

I have been using sulphite of soda in many of the malarial fevers, which have been quite frequent in this neighborhood this fall. I find the results quite satisfactory, not a grain of quinine being necessary. It has appeared to me that cases thus treated are less subject to a relapse; the career of fever is cut perceptibly short, and convalescence immediately begins. I take the tongue of the patient as my guide board for the administration of this salt. When I find it presenting a broad, flabby appearance, with pale texture, and covered either with a pasty white, yellow, or brownish coat, with bad taste in mouth and fullness of stomach, sulphite of soda is my remedy; and with these signs I regard it as almost an infallible cure. But if the condition of the tongue be different from that here described, it will do more harm than good. It is absurd to administer it to a patient whose tongue is red, red-edged with fur in center, or even covered with fur entire, while the body of it is red, or in which red papillæ are projecting up above the coating. There is nothing that will clean off the tongue quicker than this salt.

In properly selected cases it acts as a sedative, nervine, sudorific, and anodyne, bringing down the quick pulse, lessening irritability, cooling the burning skin, and soothing the aching body. My mode of giving this remedy is to use about sixty grains, divided into ten powders; one powder given every two hours, in mucilage, albumen, or slippery elm tea.

## DISINFECTANTS.

### EXPERIMENTS DESIGNED TO TEST THE VALUE OF CERTAIN GASEOUS AND VOLATILE DISINFECTANTS.

By George W. Sternberg, Surgeon U.S.A.

The following experiments, designed to test the value of some of the most commonly used disinfectants, were commenced by the writer in 1876. They are now resumed by direction of the National Board of Health, and the results will be reported from time to time:

When disinfection is practiced in ships, dwellings, and hospitals, for the purpose of destroying the virus of some infectious disease, other measures are commonly resorted to as well, such as ventilating, scrubbing, whitewashing, and painting, so that the result, if successful so far as the non-occurrence of subsequent cases of the disease is concerned, cannot fairly be attributed to the action of the disinfectant employed; and it is difficult to determine what share, if any, the so-called disinfectant has had in the accomplishment of this result. It is well known to sanitarians that methods of disinfection have often enjoyed the confidence of the public and even of accomplished physicians, which are demonstrably inefficient, and consequently harmful, as giving false confidence and supplanting other and really efficient methods. As examples of this may be mentioned the chlorine saucers which it was formerly the fashion to place under the beds in hospital wards, and the piece of flannel saturated with a few drachms of carbolic acid, which is still frequently hung up in the sick room by order of the "doctor." No one will deny that chlorine and carbolic acid are, under certain circumstances and in certain quantity, valuable disinfectants. The protest made here is against their use in demonstrably insufficient quantity with the unjustifiable assumption on the part of physicians and their patients that disinfection has been practiced, and that responsibility as to the occurrence of subsequent cases of the disease is at an end after such disinfection.

It is evident, then, that those disinfectants which enjoy the most reputation should be tested by some method other than their use in the sick room, and that, if possible, exact data should be obtained to serve as a guide in their employment.

The main difficulty in such an undertaking is to obtain a test which will be accepted as satisfactory. The power to destroy the vitality of bacteria is a test of value, as indicating the arrest of putrefactive processes, but, in the present state of science, cannot be accepted as proving a power to destroy the specific poisons of the infectious diseases. It has been used in some of the following experiments, and will be used in future for a comparison of results with those obtained from other tests believed to be more trustworthy. These tests depend upon the power of the disinfecting agent to destroy the potency of the vaccine virus as shown by vaccination, and of the septic poison as shown by inoculation experiments.

It may probably be safely assumed that the infectious material of small-pox would be destroyed, so far as its specific action upon man is concerned, by any substance which is capable of neutralizing the potency of vaccine virus, if it be subjected to the action of the particular disinfectant used under the same conditions as to temperature, moisture, quantity of disinfectant, amount and physical condition of virus (wet or dry, in powder or in masses, etc.) The inference may not be justified that what destroys the infectious material of small pox will destroy the specific poison of the other infectious diseases, but there is at least a strong probability in its favor, and no better test can perhaps be found.

The apparatus used in the following experiments is a simple air-chamber, having a capacity of 646 cubic inches, 18·62 pints, or 10·58 liters, and intended to represent the apartment to be disinfected. This air-chamber is provided with a close-fitting door, to permit the introduction of the vaccine virus, etc., and has openings closed by corks for the introduction of gases. The top and sides are of glass, and the glass top has a perforation closed by a valve upon the inside of the box, but operated from the outside.

This is for the purpose of permitting experiments upon bacteria, etc., without opening the air-chamber, into which a given percentage of some disinfectant has been introduced. To accomplish this a watch glass containing a drop of the fluid to be experimented upon (*e. g.*, putrefying meat-juice filled with bacteria) is inverted over this opening, and the valve is opened, thus exposing the concave surface of the watch-glass to the atmosphere of the interior of the box. A microscope, mounted upon the air-chamber as a stand, permits the observation of bacteria upon the inverted watch-glass while exposed to the disinfectant.

*Experiment* 1. Drop of water containing actively moving bacteria exposed over aperture in top of air-chamber, on inverted watch-glass; one sulphur match burned in air-chamber; all movements of bacteria had ceased at end of five minutes; watch-glass removed from over aperture; no movement four hours later.

*Experiment* 2. A similar drop exposed for two minutes. All movement had ceased at expiration of this time; a few bacteria moving at the end of four hours.

*Experiment* 3. A similar drop exposed for one minute. Bacteria still active; four hours later still active. Exposed again for four minutes to $SO_2$, produced by burning half a match (split) in air chamber; all motion had ceased at expiration of this time.

*Experiment* 4. A similar drop, exposed to $SO_2$, produced by burning one grain sulphur in air-chamber; all motion arrested in one minute.

*Experiment* 5. The same, burning one-eighth grain sulphur in air-chamber; all motion arrested in six minutes.

*Experiment* 6. Drop of infusion of meat, containing innumerable active bacteria (*B. termo*) exposed on inverted watch-glass over aperture in air-chamber; one-fourth grain of sulphur burned; motion ceased in eight minutes.

*Experiment* 7. The same repeated, burning one grain of sulphur in air-chamber. Motion ceased in two minutes. Experiments 8 and 9, same repeated with same result.

*Experiment* 10. The same, with one-half grain sulphur burned in air-chamber. Motion ceased in two minutes.

*Experiment* 11. Same, with same result.

*Experiment* 12. One fluid drachm of pure carbolic acid in watch-glass placed on floor of air-chamber. Drop of fluid containing bacteria exposed on inverted watch-glass over aperture. Bacteria still active at end of twenty minutes.

*Experiment* 13. Drop of vegetable infusion containing bacteria exposed to fumes of carbolic acid from a rag suspended in air-chamber. Amount used, eight drops impure acid. Motion ceased in twenty minutes.

*Experiment* 14. One drop of pure carbolic acid placed within one-eighth of an inch of drop of water containing bacteria in watch-glass, which was inverted on glass top of air-chamber (aperture closed). Motion of bacteria ceased in five minutes.

*Experiment* 15. Liquor ammoniæ in watch-glass placed on floor of air-chamber. Drop of water containing bacteria exposed over aperture. All movement ceased in three minutes.

*Experiment* 16. Bacteria in drop of putrefying meat infusion exposed over aperture with one ounce chloride of lime in a saucer on floor of air-chamber. Bacteria still active at end of thirty minutes.

*Experiment* 17. Watch-glass filled with infusion of meat swarming with bacteria of putrefaction placed in air-chamber, the watch-glass resting upon one ounce of chloride of lime in a saucer. Bacteria still active at end of thirty minutes. At end of one hour movement sluggish. In one hour and thirty minutes all movement had ceased.

*Experiment* 18. Above repeated with same result.

*Experiment* 19. Drop containing bacteria exposed to fumes of five drops of impure carbolic acid from rag suspended in air-chamber; equal to forty-six fluid ounces in a room 12 feet square and 12 high. Movement ceased at end of one hour.

*Experiment* 20. Above repeated. Motion ceased at end of thirty minutes. (Smaller drop, and more time allowed for volatilization of carbolic acid.)

*Experiment* 21. Above experiment repeated with same result; motion ceased in about thirty minutes.

*Experiment* 22. Experiment repeated with three drops of impure acid; motion ceased in one hour and ten minutes.

*Experiment* 23. Vaccine virus, quite fresh, rubbed up with glycerine, and divided into two portions. One portion exposed for twelve hours to $SO_2$, produced by burning one-fourth grain of sulphur in air-chamber; three children vaccinated on the following day with this virus, also with the virus not exposed to sulphurous acid gas. *Result:* Examined children on seventh day, and found in each case a characteristic vesicle from the insertion of virus not exposed to $SO_2$, and a completely negative result from virus exposed in air-chamber.

*Experiment* 24. Fresh vaccine virus, rubbed up with glycerine and divided into two portions: One portion placed in air-chamber for twelve hours, exposed to fumes of five drops of carbolic acid volatilized from a rag suspended in air-chamber; five children vaccinated the following day, each from both portions of virus in two different places. *Result:* Examination on seventh day showed eight characteristic vesicles from the ten insertions; one failure from carbolized virus, and one from non-carbolized.

*Remark.* These experiments upon vaccine virus are now being continued, with the kind assistance of Dr. Smith Townshend, Health Officer of the District of Columbia.

## HYPODERMIC INJECTION OF ETHER IN SCIATICA.

IN the Cincinnati *Lancet and Clinic* Dr. Whittaker reports the following case, illustrative of this treatment in a case of sciatica which had resisted the ordinary treatment for that disease, such as quinia, hypodermic injections of morphia, iodide of potassium, arsenic, belladonna, wine of colchicum, electricity, and counter irritation.

J. McG., married, thirty years of age, farmer, nervous temperament. Present condition emaciated, loss of appetite, loss of sleep, intense pain along the whole tract of the left sciatic nerve, and radiating upward from the exit of the nerve under the pyriformis muscle to the sacral and lumbar regions. Muscles of the leg and hip considerably atrophied; temperature much reduced, so much so that the patient complains of coldness and numbness. The system under the influence of morphia, which has been kept up about a month.

The morphia was immediately withdrawn and injections of ether commenced. First injection of fifteen minims immediately produced warmth and reduced the pain, and the patient slept soundly that night, for the first in two weeks. Afterward used five injections on the five days succeeding, one each day, averaging twenty-five minims each. Improvement continued steadily. Patient put on comp. phos. pil. and iron. Appetite immediately returned, sleep returned, use of leg gradually returned, muscular atrophy disappearing, and he is now well. No abscess formed, only slight callous forming around the puncture.

## THE EAR.

### UNINTERRUPTED WEARING OF COTTON PELLETS AS ARTIFICIAL DRUM-HEADS.

By CHARLES HENRY BURNETT, M.D., Philadelphia.

THERE has never been but one useful kind of artificial drum-head, and that is the cotton pellet of Yearsley. Other forms have been devised, and apparently have been of service, though only to a limited degree. Aurists of the present day, if they employ any form of artificial drum-membrane, find most satisfaction in the cotton pellet. Very little, if any, modification of the rules governing its use, as given by Yearsley,* has been suggested. In fact, Yearsley's rules need nothing but some additions. In the work and place just quoted he has condensed his experience of a number of years into seven rules or reasons, which I venture to give *in extenso:*

"I claim for moistened cotton-wool a superiority over all other substances, as the best material to be used, for the following reasons: 1. It is more easily applied. 2. It is simple, safe, and cleanly. 3. It retains its proper position longer. 4. It causes no irritation, but, on the contrary, a feeling of comfort. 5. It produces no noises in the ear in the acts of eating or talking. 6. It cures the discharge of the ear which generally attends loss of the membrana tympani. 7. It produces the highest degree of hearing of which a patient with perforated membrana tympani is susceptible."

He next says: "Any substance will produce the desired effect, if applied so as to support the remaining portion of the membrane or the ossicula; but cotton-wool is the best, for the reasons already assigned."

To these seven reasons there should be added that the application, removal, and renewal of the cotton pellet should be done only by a skilled physician properly supplied with a forehead mirror and delicate instruments, with the use of which he is thoroughly familiar, and, after the cotton-pellet has been successfully adjusted, it should be worn as long as possible by the patient, without removal or manipulation on his part, of any kind. Another very important consideration in the successful use of cotton pellets is, that the ear must have ceased to discharge before they are introduced into it.

It must be borne in mind that Yearsley had not absorbent cotton at his command, nor had he a well-arranged forehead mirror, and yet he obtained excellent results, as is very well known by all the world. Of course, he was misrepresented by his contemporaries; quacks seized his idea and most notoriously failed, thus, of course, throwing discredit on the valuable remedy he had introduced to the profession; and some members of the latter body curtailed the application of Yearsley's artificial membrane by devising vastly inferior ones, which, with a great spirit of rivalry, they vaunted and succeeded in obtaining a place for. It was thus the inferior artificial aid known as Tonybee's came into notice. Yearsley's defeating suggestion was that this instrument should be applied by the patient, which, of course, implied that any physician could apply it.

This suggestion was not incorporated in his "rules," but it opened wide the way for mistakes in application, disadvantageous forms of the artificial membrane, and, of course, finally, great discouragement to its use, and, perhaps from some quarters, condemnation of all forms of artificial membrana tympani.

So far as my own experience is concerned, nothing but the cotton-pellet drum-head has ever produced any good results, unless I except the paper-disk drum-head of C. J. Blake; and this, having so many advantages kindred to Yearsley's cotton pellet, has proven of value in my hands, and I believe it has a useful future. But my widest experience has been with the cotton pellet, and of this I wish to speak.

It will be observed that when, in 1863, Yearsley formulated his experience with the cotton pellet, into his seven "reasons," he omitted saying anything about the patient's adjusting their own pellets, nor did he allude to the period a pellet, once well placed, might be worn. By implication he permits patients to introduce an artificial drum-head into their ears, and this also includes frequent adjustment of the same. Originally, from 1848 to 1853, he distinctly enjoins daily removal and renewal of the cotton pellet; but this has not seemed necessary nor desirable in all instances in my experience, and in proof of this I adduce the following cases:

CASE I.—Josephine H., an English girl, aged 16 years; is going to school, but is impeded in advancement in her studies by hardness of hearing in her right ear. Her mother states (December, 1875), that she has been liable to attacks of earache, discharge of matter, and dullness of hearing on that side for some years.

An examination with ear-funnel and mirror reveals a chronic muco-purulent discharge from the tympanum, with a perforation in the lower and hinder quadrant of the membrana tympani, about two mm. in diameter. Hearing reduced to a few paces. Moderate syringing at home, and the use of drops of a solution of sulphate of zinc (3 gr. to ℥ i. water) checked the discharge in the course of a few weeks, but the hearing was not much improved. The mucous lining of the drum cavity was still red, and looked raw; and in order to protect it from the winter weather then prevailing, I laid over the perforation a small pellet of cotton, with a diameter slightly greater than that of the perforation.

This improved the hearing greatly, and the pellet was allowed to remain over the perforation for some days. In the course of a week the cotton pellet was still in proper position, the hearing remained very good, and the ear felt more comfortable, *i. e.*, not tender on exposure to the open air. In the course of a few weeks, with a coryza, a little discharge came from the ear, washing away the artificial drum head. But the inflammation was soon allayed as before, the discharge checked, and a cotton pellet soon applied again. I did not see the patient for some weeks, but when I did inspect her ear again the pellet was in proper position, the hearing was very good, and the membrana tympani around the cotton pellet looked dry and normal. Upon removing the cotton pellet the perforation was found to have grown smaller; another pellet was put over it, and the patient was not seen again for some weeks, when it was observed that the cotton pellet was in good position and the ear in every way doing well. Some months later the patient called again for inspection, when, upon removing the small pellet of cotton, which had been worn all the time of her absence from me, the perforation was found to have entirely healed, without a flaccid cicatrix, but with a properly tense renewal of the membrane. And this good condition of the ear persisted for a year longer, after which time the patient has been lost sight of.

This case shows the very important and valuable functions of the permanent cotten pellet: 1. That it improved the hearing; and, 2. That while aiding the hearing it stimulated the closing of the perforation in the drum head. And how simple the treatment!

CASE II.—Peter S., aged 58 years, a manufacturer of chemicals. Is almost totally deaf in both ears from a run-out purulent process of great duration. In the right ear, where the membrane is almost entirely destroyed, a little portion in the region of the malleus alone remaining, with the ordinary peripheral rim of the annulus cartilagineus, a large cotton ball, slightly moistened with glycerine, was placed. The other ear could not be improved by the cotton pellet. With the right ear thus treated his hearing rose to several feet for words of ordinary tone, and the pellet of cotton, thus fortunately placed, he wore from August 30 to October 13 following, and the patient was able, during this period, to hear all that was addressed to him in the laboratory. In this case there is offered a good example of the possibility and convenience of a prolonged wearing of the artificial drum head.

CASE III.—December 3, 1878. Mr. J. M., aged 35, states that within a year he has grown deaf, after an attack of acute otitis media, first on the right side, and then on the left. He attributes his aural disease to the use of the nasal douche, which his physician allowed him to use with *great pressure*, for the cure of naso-pharyngeal catarrh. The patient is phthisical.

On examination I found, on the right side, a large perforation in the anterior quadrant of the membrana tympani, the latter being retracted, and the hearing reduced to one foot for the voice at ordinary tone.

On the left side two perforations were found in the membrana tympani, one in the anterior, the other in the posterior inferior quadrant. The remnant of the membrane was silvery and dry, and not so retracted as the other; the mucous membrane of the tympanic cavity was very red. Hearing three feet for the ordinary voice. The mucous membrane of the pharynx was purplish red, and a copious, white, frothy mucus flowed from behind the velum palati. There was no discharge from either ear. Eustachian tubes easily pervious to inflammation by Valsalva's method.

A pellet of absorbent cotton was placed dry over the perforation in the right membrana tympani. The ear was quite sensitive to the pressure of the cotton at first, but in a few moments the pain passed off. The hearing was not improved immediately by the artificial membrane, but, after wearing it as I placed it, for two days, the hearing gradually became better, until it was found to be nearly normal. This continued for six days, when, after gargling one morning, the patient said his hearing in the right ear had become dulled. I was therefore induced to remove the pellet, with a view to readjustment, and the hearing was immediately thereupon reduced markedly, and a fresh cotton pellet did not immediately improve it, thus showing what I have observed in other cases, that it is best not to remove a cotton pellet when a slight diminution of hearing ensues, so long as the pellet seems to be in the position in which it was placed by the surgeon, and no discharges have soaked it.

The second pellet was removed in twenty-four hours, as it did not seem to improve the hearing, and a new and larger one was inserted. In this case each pellet had been placed so as to leave a small crescentic opening at the anterior part of the perforation.

The third pellet was packed farther into the tympanic cavity, and back toward the stapes, *i. e.*, upward and backward. This made the hearing better, but not as good as the first pellet, which I regret I moved at all, as, during all this unnecessary manipulation, no discharge was coming from the drum cavity. In fact, the first pellet had become slightly adherent to the membrana tympani from the drying of a little of the natural secretion of mucus from the tympanum.

The last pellet of cotton was allowed to remain over the perforation until Dec. 28, 1878, a little over two weeks, when it was removed in order to put in a clean one. The latter improved the hearing as much as its predecessor. At this date a cotton pellet was placed over each perforation in the left membrana tympani, and the patient then made a journey in the depth of winter, far out in the West, and I did not inspect the ears until Jan. 21, 1879, nearly one month later. The hearing was slightly improved on the left side, but not so much as on the right side, by the artificial aid. But both ears had been protected during the cold and exposure of a winter journey.

On the 21st of January, 1879, twenty-four days later, after the patient's return from the Western tour, all the cotton pellets were removed, as they had become unclean from

* "Deafness," etc. London, 1863, p. 262.

mucous absorption and from cerumen, which the ears secreted to a great extent, and it was observed that the two perforations in the left membrane had united to form one large heart-shaped one. Fresh pellets were adjusted as before, with the same results, viz., considerable improvement in the right, with loss in the left ear.

On March 15, 1879, fifty-three days later, the process of renewal was gone through with, with similar results, the mucous membrane of the drum-cavities in the meantime having taken on a healthier look and action.

On April 11, 1879, twenty-eight days later, the cotton pellets were taken out of and not reinserted into the left ear, as the hearing had become better, independent of their pressure, but could not be augmented by their insertion.

A fresh pellet in the right ear, covering about a third of the drum-membrane in the region of the perforation, improved the hearing on this side as theretofore.

On the 27th of May, 1879, forty-seven days later, the cotton pellet was taken out of the right ear, and the hearing having reached a permanent improvement, with the cotton pellet out of the ear, and the approach of warm weather rendering such protective influence unnecessary, the ears, now permanently better, were left to themselves.

On the 17th of November, 1879, the patient informed me that his hearing had remained very good all summer, and that there had been no pain or discharge from the ear since I had seen him. The hearing was found to be nearly normal, though the perforations persisted in each membrana tympani. The mucous membrane of each drum-cavity was congested, and there was some naso-pharyngeal catarrh, but the condition of the ears did not seem to demand any artificial drum-membrane. Here was a case that seemed to show the advantages of long periods of wearing the cotton pellet as a protector to the inflamed drum-cavity and as an aid to hearing during the process of quasi-healing.

CASE IV.—Mr. L. S. J., aged 83, a retired manufacturer; has been liable to attacks of pain and discharge, in the right ear, for a number of years, usually whenever he had a severe cold in his head. The hearing long ago became greatly impaired on this side, and as the hearing has gradually failed on the left side, with the sclerotic affection of old age, he consulted me on June 4, 1879. On the right side the membrana tympani was found largely perforated in its front half; its remnant was dry and pale pink in color; the mucous membrane of the drum-cavity was not very red, though decidedly congested. There was no discharge from the ear, and the wall of the auditory canal was covered with very adherent, hard, dark scales—probably composed of purulent and epithelial debris, stained by nitrate of silver, which had been used by his family physician, on this side, to stop the discharges from time to time.

The left membrana tympani was opaque, gray, indrawn, and lusterless.

H. for ordinary voice on right side = 6 in. H. for ordinary voice on left side = 6 in.

It was proposed to try the effect of an artificial drum-head on the right side, and on the 6th of June a small pellet of cotton, moistened with glycerine and water (1–4), the size of a small pea, was laid firmly over the perforation in the right drum-head.

This instantly improved the hearing to three or four feet for the ordinary vocal tones, and enabled the patient to hear conversation at table, which he had been deprived of for a long time. He was asked not to disturb the cotton pellet, and did not, wearing it faithfully for twenty days, when I saw him again.

It was found that with a little cold his ear felt uncomfortable, and that he could not hear so well; and also on the anterior wall of the auditory canal, on the dark scale of adherent matter, a patch of aspergillus nigricans had sprung up. The entire scale was now easily lifted out, having been softened by the contact of a little glycerine and water. Fearing that spores of the fungus might have gotten into the depths of the canal and in the cotton pellet, the latter was removed and the entire canal and tympanic cavity subjected to instillations of alcohol and water in equal parts, three or four times daily for three or four days. No further signs of aspergillus showing themselves by June 30, a fresh cotton pellet was placed in the ear as before, and with the immediate improvement in the hearing.

The auditory canal was now entirely clean, with bare pink walls, but a close watch was kept for the reappearance of the inveterate parasite. By July 3 a little patch of delicate down of aspergillus was observed on the floor of the auditorp canal near the artificial drum-head; the latter extended over the perforation, and down as far as the floor of the canal. This patch was simply deluged with a drop of absolute alcohol on a tuft of cotton on the cotton holder. This controlled the growth from spreading; but on the 7th, the patch still being plainly visible, though smaller, it was treated in the same way with absolute alcohol, the cotton pellet all this time being in perfect position over the perforation, and acting as a great aid to hearing. The aspergillus showed no signs of growing over it, and it occurred to me that perhaps the mere presence of a pellet of absorbent cotton, deprived as it is of oily matter, proved an unpropitious soil, and further, acted as a mechanical hinderance to the inward growth of the fungus toward the drum-cavity.

On July 11 the ear was found to be in good condition, the cotton pellet still clean, in the position it was put in, and aiding the hearing very markedly. On July 14, the patient was seen for the last prior to a long visit at Sharon Springs. The cotton pellet put into the ear on June 30 was still acting its part as aid and protector, and was allowed to stay in the ear. The summer was then passed at the Springs, and the cotton pellet continued to act well, and was still there in November, 1879.

This beneficial effect of prolonged wearing of cotton pellets I have seen in many other cases, but these four, presenting, as they do, good examples of such a use of the artificial membrane in people of different ages, occupations, and social surroundings, seem to be enough for illustration of the point it is desired to enforce.

It may, therefore, be concluded that, when the membrana tympani is perforated, and the discharge from the tympanum has ceased, a cotton pellet will do more good when properly adjusted by the surgeon and let alone, than if manipulated every day, and that such artificial drum-membranes act both as temporary aids to hearing, and favor by protection, and, perhaps, by gentle stimulation, the healing of the chronically inflamed mucous membrane of the drum-cavity, and the closing of the perforation of the drum-head; though general improvement of the ear and hearing may ensue without the later result.—*Journal of Otology.*

## THE EFFECTS OF A FIXED IDEA.

THE following case, showing the curious effect of the imagination on a healthy and strong man, may be interesting to your readers, and throw some light on several cases of hydrophobia lately reported.

A gentleman, aged fifty-six, was away from home, and was dressing in the morning, when his mouth and nose suddenly filled with blood. He then became aware that his false teeth, which he seldom removed at night, were missing. He fancied he felt them in his pharynx, and imagined he had swallowed them during sleep. He became greatly alarmed, and immediately sent for my partner, Mr. Atkins, to whom he told the above story, and drew his attention to a hard swelling behind the larynx. Mr. Atkins examined this, which was certainly suspicious, and thrust his finger as far down the throat as possible without feeling anything internally. The patient persisting that the teeth were in the pharynx, I was telegraphed for, to bring instruments, etc.

When I arrived I found the patient in bed, with intense anxiety depicted on his countenance, with a rapid, small pulse; and, when I asked him a question, he motioned for pen and paper to communicate with me. Neither I nor Mr. Atkins could now discover any external swelling, though the patient implied by gesture that it was apparent to his own touch. I examined him with the laryngoscope with difficulty, the throat being very sensitive; and, seeing no signs of the missing teeth, I asked him why he could not speak, when he replied, "Oh! I can speak; but Mr. Atkins told me not to talk." I now introduced a probang into the throat, and the patient said he felt me touch the teeth, just behind the cricoid cartilage. I was afraid to attempt to push the probang forward, as the teeth were described as almost a complete set of lower molars; so I bent a 10-inch military silver probe and hoped to hook the teeth up. I once or twice struck something which felt hard, and the patient then said that I moved them, but the spasms both of pharynx and larynx were so severe, and the mount of glairy mucus ejected was so great, I had scarcely got the probe down before I had to withdraw it. After a few more explorations I came to the conclusion that it was an elongated horn of the hyoid bone and no foreign body that I struck against, and I was confirmed in this opinion by finding that the patient could swallow fluids without any difficulty. I told him I thought he was mistaken, and ordered a search of the room, when shortly the missing teeth were found on the top of a chest of drawers.

The patient's surprise may be imagined. All his symptoms immediately disappeared; he dressed and ate an excellent lunch.

My explanation of this curious case is that the patient's nose commenced bleeding when he was dressing; this first drew his attention to the absence of his teeth. He forgot he removed them the night before; being in a strange house he did not know where to look for them. There was probably a clot of blood in the pharynx, and this imagination magnified into the teeth. Some spasm of the pharynx produced the hardness he and Mr. Atkins felt on arrival. The rest was purely the effect of a fixed idea, which in this case was fortunately removable by the production of the supposed cause; had that not been possible, I can quite understand, from the nervous condition of the patient, that even the dreadful symptoms of hydrophobia might (had that been the fixed idea) have been produced, the excessive secretion from the pharnyx having already commenced.—*E. M. Wrench, in London Lancet.*

## MICROSCOPIC ORGANISMS.

By M. PASTEUR.

THE bacteria of carbuncle and the organism producing the so-called cholera of poultry can bear temperatures of —40° without losing either virulence or their power of multiplication.

## ON THE NOXIOUS ACTION OF ACID VAPORS ON VEGETATION.*

By DR. G. LUNGE.

UNDER the above title, Mr. Hasenclever, the managing director of the Rhenania Chemical Works, near Aachen, has published a paper, the contents of which are not merely of great interest, but of real importance, for the British alkali making districts. Since, hitherto, only a very short notice of this paper has been published by the *Chemical News*, it will hardly require an apology if I place its essential points before the society in a more ample form.

Hasenclever commences by admitting at once the noxious action of acid gases upon vegetation, exercised wherever large quantities of such gases are given out. This takes place especially in calcining sulphurous ores and mattes; large quantities are also given out by some chemical works. Complaints have also been made in some cases against ultramarine, glass, brick works, and generally against those manufacturing establishments in which a large quantity of coals is consumed. The noxious action of acid gases on vegetation is further proved by the investigations of Stöckhardt, Freytag, and Schroeder (mentioned in my "Treatise on the Manufacture of Sulphuric Acid and Alkali," vol. i., p.110–112 of the English edition). Hansclever himself gives excellent colored drawings, showing the outward changes produced by acid vapors on the leaves of the carrot, Scotch fir, oak, and rose. He adds pictures of tussilago leaves damaged by flue dust, and of beech leaves damaged by frost, both of which exhibit an appearance altogether similar to that of leaves damaged by acid vapors. Since, moreover, autumnal decay, fungi, insect stings, and other influences may bring about quite similar appearances, great caution is needed before fixing upon any one of these causes as the real one; and instances are given of considerable mistakes made in this way.

When the functions of the leaves are disturbed by these spots, whatever be their cause, the trees suffer in their growth; and, if this goes on for several years, they die altogether. The decrease of growth can be observed, without cutting down the trees, by taking a sample of it by means of Pressler's auger, which shows the single annual rings.

In many places, where the action of noxious gases is quite out of the question, plantations of trees exhibit the appearance of suffering. This may be produced by the tops of some of the trees projecting too far, which interferes with the growth of their neighbors; by leaving single trees standing after cutting down those around them; and, more especially, by the drought consequent upon the regulation of water courses, the lowering of the level of lakes, and the ordinary effects of mining; and also, in towns, by the hardening of the ground round the roots produced by the street traffic. Wherever the wood is impoverished, by taking from it the decayed leaves and branches without imparting to it some kind of manure, a deterioration of the trees must necessarily follow.

Undoubtedly there are some cases where none of the causes just mentioned is present, and where acid vapors must be blamed for the destruction of vegetation. It is certain that this takes place more easily in damp than in dry weather. But the proof that such destruction is due to acid vapors, frequently sought to be obtained by a comparative estimation of chlorides and sulphates in damaged and sound plants, is anything but easy and certain. It has not been established yet that an increased percentage of acid in the leaves is regularly accompanied by a decrease of growth; neither is it known what is the maximum percentage of chlorine and sulphuric acid that leaves may absorb without being corroded. König found in the fir woods, near the Lethmathe Zinc Works, relatively considerable quantities of sulphuric acid in apparently healthy trees, while Schroeder found only half as much sulphuric acid in similar trees, on the Harz, which had been destroyed by noxious vapors.

No doubt, whenever much sulphur dioxide is given off, whether by the calcining of ores or in some other way, there is a good deal of sulphuric acid found in the plants. Similarly high chlorides are found near chemical works which decompose common salt, and near potteries which glaze their ware by means of salt, but both sulphuric acid and chlorine are also found in ordinary coal smoke. It is perfectly well known that formerly when the atmosphere must have been purer from the absence of a highly developed industry, the use of coal was disliked, and even here and there prohibited on account of its "pestilential" smoke. Mohr asserts that the obelisk of Luxor, erected in 1836, on the Place de la Concorde, at Paris, has suffered more in thirty-six years there than during as many centuries in Egypt. Rhenish and Westphalian coal contains on the average 1½ per cent. of sulphur (usually in the shape of pyrites), which must pass into the air as sulphur dioxide. The injurious effect of this is frequently felt either where coal is burnt in large quantities, or where the smoke, as in narrow valleys, is not specially diluted by air. This is proved by special instances from Stöckhardt and others. The statements of Dr. Angus Smith are also quoted, according to whom London air contains in a million of cubic meters, 1,670 grammes sulphuric acid, and Manchester air, 2,518 grammes.

Chlorine also regularly occurs in coals, and is not found in their ashes, but expelled along with the volatile constituents. The chlorine of gas water must be reduced to this origin. There is also chlorine in blast furnace gases.

Soot seems to be quite harmless by itself, as proved by Stöckhardt's experiments; but becomes very injurious to plants when containing metallic sulphates, as is often the case in industrial districts.

Hasenclever now turns to the question, How the injurious effect of acid vapor upon vegetation, whether arising from the direct evolution of such vapor or from coal smoke, may be best prevented? Tall chimneys are quite inefficient in the case of large quantities of vapors; the dilution by air, even when sufficient in fair weather, fails to act in damp weather Only in isolated establishments, and with moderate quantities of vapors, does dilution by tall chimneys prove satisfactory. Washing out the acids from coal smoke has not been found practicable. The legal enactments for the complete combustion of smoke enforced in some English towns have done some good, but have only diminished the *black* smoke. In Germany, at watering places, and other towns or villages which depend upon the concourse of visitors, the establishment of factories is not permitted, or is at least restricted. Dr. Angus Smith frequently points out that too great an accumulation of industrial establishments in any one locality should be avoided. At Hanover (and some other large German towns) the existing factories are not interfered with, but no new factories are licensed within the urban district.

All this refers to coal smoke. The sulphur dioxide escaping from glass works in enormous quantities is nowhere condensed; it is too much diluted for the condensation to be effectual. In vitriol works the escape of sulphurous and sulphuric acid has been very much lessened by the introduction of Gay Lussac towers. But considerable difficulties still exist in the case of copper, zinc, and lead smelting works. In Germany many of these now calcine the ores in Gerstenhoefer's or in Hasenclever and Helbig's kilns, and thus utilize a portion of the sulphur as vitriol. But even then the condensation of the calcining gases is not perfect, and further progress in this direction is very desirable. Still there is a consid erable difference between the desolate aspect presented by the neighborhood of those smelting works which do not condense at all, and the field and garden culture observable close to the other kind of works, although even these interfere with fir woods, fruit bearing trees, and some other kinds of trees.

We now come to the escape of hydrochloric acid from factories decomposing common salt by sulphuric acid. Everybody knows the former state of matters in this respect as laid bare by the Belgian Commission of 1855, and the reports of the British alkali inspectors since 1863. The large escapes formerly complained of can be directly traced to the fact that at that period far more hydrochloric acid was produced as an involuntary by-product than could be utilized or sold. In Germany, at least, this is no more so; the demand for hydrochloric acid on the part of color, copper, glue, dye, and sugar works has increased to such an extent that some factories produce this acid as their principal article, making soda ash only as a by-product. This is best proved by the fact that no special legislation on the condensation of hydrochloric acid was thought necessary in Prussia, although the question was mooted in its proper place, because it was considered that the self interest of the manufacturers was quite sufficient to insure efficient condensation. The German alkali works usually possess even a larger condensing space than that laid down as sufficient by Dr. A. Smith, and no damage worth speaking of is done to vegetation in their neighborhood where they are isolated; but where they are situated among many other industrial establishments they are sometimes singled out, and held responsible far beyond their due, for the damage unavoidable in such circumstances.

This is illustrated by a private communication to Mr Hasenclever from Dr. Fletcher referring to the acids escaping in the neighborhood of St. Helen's. Dr. Fletcher calculates the weekly escape from—

| | | |
|---|---|---|
| Fire gases at | 800 tons | $SO_2$ |
| Copper works at | 380 " | " |
| Glass works at | 180 " | " |
| Alkali works at | 25 " | HCl |

Hasenclever himself gives a table referring to the twenty

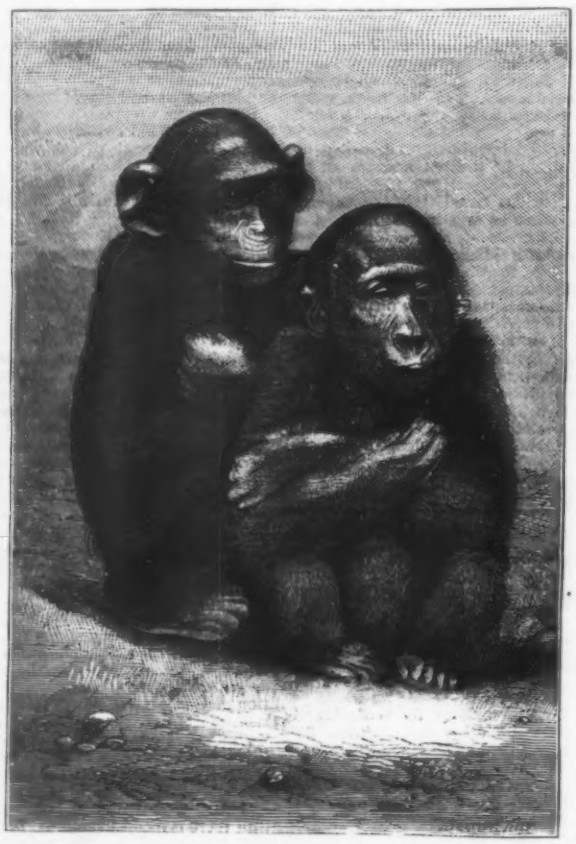
* A paper read before the Newcastle-upon-Tyne Chemical Society.

eight industrial establishments situated at Stolberg, near Aachen, on an area of 1,600 acres, whose 220 chimneys emit in twenty-four hours 34,500 kilogs. of $SO_3$ from coals, and 50,858 kilogs. of $SO_3$ from zinc works, glass works, etc., but only 480 kilogs. $SO_3$ and 750 kilogs. of HCl=4 per cent. of the total acids from the Rhenania alkali works.

Hasenclever concludes by admitting that acid vapors ought to be condensed as fully as possible; also that everybody ought to be made to pay fully for any damage he may have caused; but he claims that manufacturers ought not to be harassed *beyond* their due, and he complains that public opinion is not always just in this respect. Damaged plants and trees occur in many places remote from chemical works and other industrial establishments, as proved by several photo-lithographic illustrations appended to the original, and their occurrence near such establishments should consequently not be taken as caused by acid vapors without real proof of the case.

## THE GORILLA AND CHIMPANZEE AT THE LONDON CRYSTAL PALACE.

WHETHER the Darwinian theory of the descent of man be adopted or not, everything which concerns the natural history of the anthropomorphous apes excites the highest degree of interest. We could have no greater proof of this than the eagerness with which the crowds flocked to the London Crystal Palace some weeks ago to view the young gorilla and chimpanzee which were there on exhibition. Unfortunately the severe climate of London did not agree with these poor animals, and they soon succumbed, like most of their predecessors, to pulmonary phthisis. Before their death, however, Messrs. Negretti & Zambra succeeded in taking faithful portraits of them by means of instantaneous photography. We herewith publish a reproduction of a proof printed from the very successful negative. To this we may join a few words concerning the history of the two



THE GORILLA AND CHIMPANZEE AT THE LONDON CRYSTAL PALACE (From a Photograph).

unfortunate animals. Both of them were captured on the west coast of Africa. The chimpanzee was a male, and the gorilla a female. The former was supposed to be about two and a half years of age, and the latter about a year and a half. When the gorilla stood upright she was about 2 feet high, and it is probable had she lived to attain her full development that her height would have been five feet.

The two monkeys were brought to England by a Liverpool naturalist, Mr. William Cross, who sold them for the fabulous sum of $10,000 to Mr. Garcia, of Manchester. At such remunerative prices as these it is singular that all the natives of Gaboon do not betake themselves exclusively to gorilla hunting. The English correspondent from whom we borrow these few details closes his brief account as follows: "We feel a sympathetic interest in these poor creatures, who are powerless to endure the cold and the absence of a tropical sun. Our children go to witness the gambols of the monkeys in the Zoological Gardens, and imagine that these are always the same creatures that are sporting from year to year before their eyes, but they are deceived. Constantly renewed arrivals are necessary to fill up the vacancies which phthisis is constantly making in the ranks of these poor animals."

## TELLING A HORSE'S AGE.

THE safest way of determining the age of a horse is by the appearance of the teeth, which undergo certain changes in the course of years. Although it may be impossible to give any rules which will be found to be exactly correct in every case, yet the following classification is generally correct; but exceptions will occur, as for instance: A noble horse may be taken for younger than he really is, because the strong structure of all the bones makes the teeth also stronger than those of a horse of an inferior breed of the same age.

Eight to fourteen days after birth, the first middle nippers of the set of milk teeth are cut; four to six weeks afterward, the pair next to them; and finally, after six or eight months, the last.

All these milk teeth have a well-defined body, neck, and slender fang, and on their front surfaces grooves or furrows, which disappear from the middle nippers at the end of one year; from the next pair in two years; and from the incisive teeth (cutters) in three years.

At the age of two, the nippers become loose and fall out; in their places appear two permanent teeth, with deep black cavities, and full sharp edges.

At the age of three, the next pair fall out.

At four years old, the corner teeth fall out.

At five years old, the horse has his permanent set of teeth.

The teeth grow in length as the horse advances in years, but at the same time his teeth are worn away, by use, about one-twelfth of an inch every year; so that the black cavities of the center nippers below disappear in the sixth year; those of the next pair in the seventh year; and those of the corner teeth in the eighth year. Also the outer corner teeth of upper and lower jaw just meet at eight years of age. At nine years old, cups leave the two center nippers above, and each of the two upper corner teeth has a little sharp protrusion at the extreme outer corners.

At the age of ten the cups disappear from the adjoining teeth.

At the age of eleven the cups disappear from the corner teeth above, and are only indicated by brownish spots.

The oval form becomes broader, and changes, from the twelfth to the sixteenth year, more and more into a triangular form, and the teeth lose finally, with the twentieth year, all regularity. There is nothing remaining in the teeth that can, afterward, clearly show the age of a horse, or justify the most experienced examiner in giving a positive opinion.

The tushes, or canine teeth, conical in shape, with a sharp point, and curved, are cut between the third and fourth year; their points become more and more rounded, until the ninth year, and after that, more and more dull in the course of years, and lose, finally, all regular shape. Mares have, frequently, no tusks, or only very faintly indicated.

## WHAT THE CHIPMUNK DOES WITH THE DIRT.

THE editor of the *New England Journal of Education*, having offered a prize for the best answer to the above, publishes the following replies:

### A PUPIL'S IDEA.

I notice in the *Journal* an article inquiring what becomes of the dirt that the chipmunk digs out of his hole, and that the publishers are to give a copy of the book to the first one answering. By way of giving the desired information—he begins at the other end of the hole.

IRENE J. KEPHART.

Duffields, Jefferson Co., West Va.

### HE CARRIES IT OFF.

I wish to answer the editor of the "Young Folks' Cyclopædia of Common Things" (not particularly for the prize he offers, although that would be acceptable, but for the general information), that the chipmunk does not begin to dig at the other end of his hole, as the ancients believed, but actually carries the dirt off in his mouth, and the quantity removed often amounts in aggregate to half a bushel. This from the observance of a country boy who has killed them with the dirt in their mouth.

F. J. BARNARD.

162 Washington Street, Boston.

### CHIPMUNKS AND CYCLOPÆDIA.

I saw in the *Journal*, under the head of "What becomes of the dirt?" that you would give a copy of the "Young Folks' Cyclopædia of Common Things" to the first boy who would answer the question. Chipmunks have two openings to their holes, and one hole is usually in a concealed place, and in that they throw the dirt out.

I am twelve years old, and would like that cyclopædia very much.

MATHER C. HOWE.

Schenectady, N. Y.

### OTHER METHODS.

Your notice in *Journal of Education*, of Jan. 1, I read to my scholars, and to-day two bright boys (brothers) gave me an answer derived from actual observation. They say that the chipmunk usually selects for his hole a slight hill; that he commences below the top to dig, and works toward the center, and thence up to the surface. He throws the dirt from the lower hole down the slope, and when his nest is finished he closes up the lower hole entirely, using the upper for ingress and exit.

Another manner in which he makes his nest is as follows: Commencing at the base of a stone wall he makes a long gallery under the wall, making in the course of it several passages to the surface. The dirt is thrown all at the hole where he begins to dig, which, when he has completed his nest, is, as in the case of the hill, closed up and *skillfully* concealed.

As an incident, they mention a case where several men were digging a well, and in course of digging, dug across a gallery which a chipmunk was in process of making. While the men were still at work the squirrel, unaware that they had dug across his hole, *backed* out of his gallery, from the direction of the top of the mound, and fell among the men. (The well had been begun between the base and top of the mound.) The names of the boys are, respectively, Lester and Walter Skelton.

Another boy, Edgar Prouty by name, says that he has often dug into the chipmunk's nest for the nuts stored away there, and says that he has oftenest found the hole to be in the shell of a tree root which has decayed in the ground, consequently there was no dirt to remove.

All three of these boys are reliable, and have not told me this other than to get all the information they could for me. Still, however, I hope you will find it what you want, and that the boys will get the book you promise. If there is question who of the three should have the book, I think the Skelton boys most deserve it, as they have taken most pains to be correct.

CHARLES A. ESTERBROOK.

Center School, Burlington, Mass.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